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ABSTRACT

This instructional resource guide is intended to aid teachers and curriculum specialists in developing instructional materials for the first two years of preparation of electronics technicians. It is part of the secondary/postsecondary master technician program. Section I on occupational information presents general information and the electronics/electromechanical technology section of "The Forecast of Occupational Demand," which provides a variety of information about the career as it is characterized on the Virginia Peninsula. Section II contains a task list arranged in a suggested teaching sequence. Task analysis sheets, arranged by duty areas, provide performance and enabling objectives, criterion-referenced measures or test items, learning activities and steps for teaching the task, recommended instructional aids, and references and audiovisual materials. Section III describes courses based on the task analysis in section II. Course descriptions, content outlines, and suggested task teaching sequences are provided. Section IV offers information on student organizations. Section V illustrates examples of classroom management and instructional systems developed by teachers incorporating competency-based vocational education techniques into their courses and programs. Section VI contains information on the characteristics of grading and recording systems for competency-based education. Appendixes include a bibliography and listings of selected audiovisual materials and tools and equipment. (YLB)

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Instructional Resource Guide

for

Competency Based Education

in

ELECTRONICS/ELECTROMECHANICAL TECHNOLOGY

1987 REC'D

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This instructional resource guide was developed by the school divisions of Hampton, Newport News, Poquoson, Williamsburg/James City County, and York County in cooperation with Thomas Nelson Community College, New Horizons Technical Center, and local business/industry/government representatives under the guidance and direction of the Department of Education, Division of Vocational and Adult Education, and under the provisions of the Vocational Education Act of 1986 and the Master Technician contract #VA85-3-IIB3-PI-001.

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Introduction

This instructional resource guide is part of the secondary/postsecondary master technician program (2+2) and conforms to the guidelines of competency based education standards and requirements.

Standard I ROLE RELEVANT COMPETENCIES ARE IDENTIFIED AND STATED

Requires A. A validated task/competency list for each vocational program.

B. A performance objective for each validated task/competency.

Standard II COMPETENCIES ARE SPECIFIED TO STUDENTS PRIOR TO INSTRUCTION

Requires A system for providing task/competency information to students prior to instruction.

Standard III CRITERION-REFERENCE MEASURES ARE USED TO MEASURE ACHIEVEMENT OF COMPETENCIES

Requires A. A criterion-referenced measure for each validated task/competency.

B. A testing and evaluation procedure which tests the performance objective and is criterion based.

Standard IV A SYSTEM EXISTS FOR DOCUMENTING COMPETENCIES ACHIEVED BY EACH STUDENT

Requires A system containing task/competency records/profiles for student achievement in each vocational program, course, or unit.

The materials in this instructional guide comply with the state CBE standards and requirements for vocational and adult programs.

PURPOSE

The primary purpose of this guide is to aid teachers and curriculum specialists in developing meaningful instructional materials, for the first two years of preparation so that technicians will meet the basic entry level needs of the electronics technician in today's industries and those of the future.

RATIONALE

Rapid change in technology evolved from advances in electronics which resulted in automation, computerization, and miniturization of the manufacturing, retailing, and researching processes. With the adoption of these processes came the need for a technician with a sound base in mathematics and science. Recognition of this need brought business/industry/government and education together to develop a program of study to train technicians who were "systems-oriented." Preparation of this MASTER TECHNICIAN required the development of a curriculum designed to articulate the program between secondary and postsecondary levels of education to produce a technician who could:

- Adapt to changing technologies by applying comprehensive technical, scientific, and mathematical competencies in training and retraining processes.
- Use computer software and hardware to develop skills in computer programming and digital electronics.
- Master relevant skills with emphasis on electromechanical systems.

The role of secondary vocational programs will be expanded under the Master Technician Program to include preparation of students for postsecondary education in technical fields. To provide a "pretechnical" curriculum at the secondary level, the following must be included:

- Development of basic competencies required for technology, mathematics, science, and occupational goals.
- Training of students to apply basic skills in the use of tools, materials, processes, controls, and energy conservation systems.
- Provision of a real, practical, and functional study of technology.

Additionally, as stated by the Panel on Secondary Education for the Changing Workplace, ". . . the use of advanced technology becomes ever more pervasive in our economy, schools must encourage students of both sexes to acquire a firm grounding in science and technology . . . High school graduates, therefore, need the confidence that they can understand how things work. Nothing builds this confidence so effectively as the study of specific technologies and scientific principles underlying them. . . ."

When these recommendations are implemented in the secondary school there will be an increase in the number of students exposed to the study of various technologies which will likely cause a corresponding increase in the interest of technology careers.

The role of the postsecondary course of study under the Master Technician Program will be to expand upon the "basics" learned in secondary school, and to teach more highly technical areas such as lasers, fiberoptics, and robotics.

In combination, the two levels of training provide a well-rounded, systems-oriented technician who is better prepared for today's technology and the technology of the future.

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SECTION I

OCCUPATIONAL INFORMATION

Vocational education programs play an important role in the broad mission of education by acquainting students with the world of work and providing them with fundamental experiences in various occupational clusters. Students need this broad base of experience and insight into available career opportunities in order to build a sufficient awareness from which they might conduct personal assessments of work interests and aptitudes. Opportunities for expanding this base of awareness must occur in course offerings at the early secondary level, in time to assist the guidance function. The mixture of guidance, awareness, exploration, and preparation is aimed at improving the quality and relevancy in career preparation and placement. The result of these efforts is an individual who is prepared to assume a more productive and fulfilling role in society.

The contributions of the early secondary level courses to the goals implied in the mission of vocational education involve three very important aspects, without which meaningful occupational preparation would be impossible. These aspects include: an awareness of self, an awareness of the technological culture in which the individual lives, and the development of the fundamental skills contributing to the performance of an individual in contemporary society.

The awareness of self is imperative for the student to make responsible career decisions. In order to decide upon a viable occupation, the student must examine certain questions such as:

- What are my interests, ambitions, and goals?
- What are my strengths and weaknesses?
- What type of activities and experiences are compatible with my emotional physiological makeup?
- What do I want to do with my life?

Technological awareness is difficult to separate from self awareness in today's culture because our lives are so technologically dominated. An insight into and understanding of technology and its meaning, origin, nature, development, impact, and consequence for society are imperative for all individuals, regardless of their educational goals or occupational pursuits.

Fundamental Skills are those skills as basic to occupations and careers as are the three R's are to elementary education. These skills are identified as:

a. Communication skills--making presentations, interpreting drawings, developing directions, directing others, and planning with others;

b. Manual skills--constructing objects, making drawings, and testing materials and processes;

c. Social interaction skills--meeting with, leading, following, and cooperating with others; and

d. Problem solving skills--developing inquiry capabilities, developing resourcefulness, and developing evaluation capabilities.

CAREER ORIENTATION AND EXPLORATION

One of the first activities in career exploration is one in which students identify the wide variety of careers they will experience in the course. Student experiences allow exploration into several "work modes." "Work modes" is a term referring to the six ways or styles in which people perform work. As students experience various laboratory activities, they determine if the style of work performed in a given job is truly suitable in terms of their personal interests and abilities. The following description of worker characteristics compatible with each of the six "work modes" will aid students in making career decisions and future educational choices which are appropriate in light of personal interests:

(1) Mechanical Work Mode: people with good coordination who like to work with tools and machines and who enjoy seeking the fruits of their labor.

(2) Conventional Work Mode: people who enjoy short-term repetitive tasks and can work well alone, following a routine.

(3) Creative Work Mode: imaginative, expressive people who work well by themselves.

(4) Social Work Mode: sociable, humanistic people who enjoy helping and working with other people.

(5) Investigative Work Mode: people who like to analyze things and plan ahead, and who also work well with fewer number of people.

Students use these work modes as a framework through which they can tentatively judge the suitability of any occupation to their own personality characteristics. The concept of appropriate career choice is further realized through exploratory experiences directly related to current practices in industry.

GUIDANCE SERVICES

There is a clear relationship between vocational education programs and guidance resources available in the school. Guidance counseling of students assists them in making informed and meaningful choices in their selection of occupational fields or advanced educational programs. Through the use of interest inventories and aptitude surveys, guidance personnel help students assess themselves and become aware of their special talents.

CAREER PLANNING

The activities of vocational education help students clarify their career goals. Many aspects of one's personality and interests can be explored in relation to the technical and work styles of careers introduced. Students are encouraged to talk about their personal goals and interests. Other useful planning information may be obtained through investigating financial considerations, occupational alternatives, and pre-employment experiences in each individual student situation. Career planning is a concluding activity in which the student makes career choices based upon all of these considerations and selects the next course leading to a chosen career interest.

Teachers will be able to help interested students plan and identify steps leading to career choice by arranging tours of vocational centers and acquainting them with the various programs and courses available. Allowing students to observe other students and meet teachers in such programs, as well as encouraging them to interview successful people in the workforce, aids students in advancing to the next level of instruction.

OCCUPATIONAL OPTIONS

For each vocational course that is offered, there is a wide range of various occupational options available. Almost every occupation offers advancement opportunities for the person who attains special talents or additional training. Continued training can generally be pursued through evening courses provided by community colleges or through courses sponsored by corporations. These experiences may lead to advanced technical preparation programs or they may create interest in further exploration.

CAREER PREPARATION

The following outcomes of vocational programs are helpful to students in their preparation for a successful and rewarding career.

Technical adaptability is promoted through students for living and working in a technological world where there is a common need for adaptability and employability of skills.

Pride in work is learned as students build models and projects that have self-gratifying value and create feelings of worth. Recognition is provided through VICA/AIASA student competitions ranging from conducting a meeting to troubleshooting complex systems.

Positive attitudes toward work are increased through laboratory activities that illustrate the need for and benefit of work in regard to both the individual and society. Positive attitudes are enhanced through VICA/AIASA activities which allow students to meet workers from industry.

Following directions is practiced as students proceed toward completion of individual or group projects.

Abilities to solve problems are developed as students use technology to design and develop systems useful to them or other people.

Safe work practices are learned before tools are used. These skills are transferred to the care and use of machine and other equipment.

Cooperative attitudes result from seminars wherein students share and receive help with projects and from group activities in VICA/AIASA.

OCCUPATIONAL EDUCATION INFORMATION

Teachers and counselors are encouraged to use a variety of occupational information when assisting students toward a career goal.

On the Virginia Peninsula, the site of the pilot model for the Master Technician Program, the Virginia Peninsula Vocational Training Council (VPVTC) publishes a "Forecast of Occupational Demand" on forty high demand occupations for the Peninsula area. Electronics/Electromechanical technology is one of the occupations for which the VPVTC publishes a forecast.

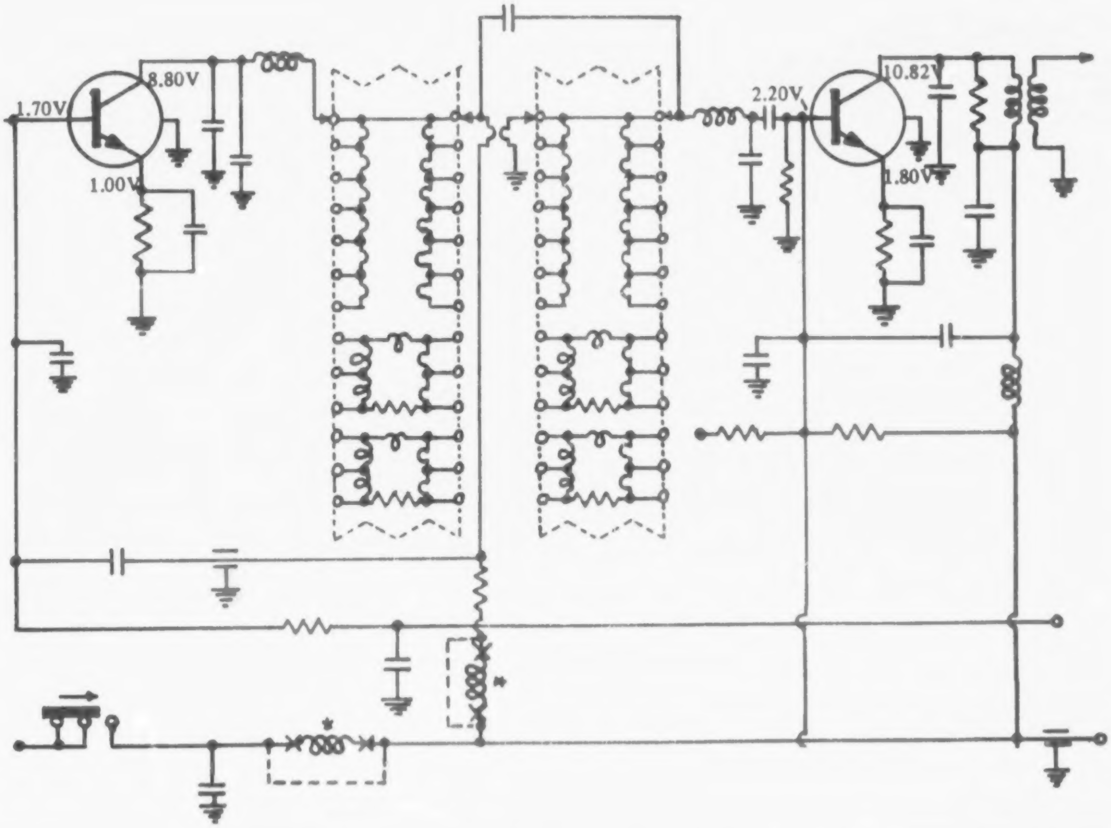
"The Forecast of Occupational Demand" is a comprehensive document containing 13 sections which include a variety of information about the career, as it is characterized on the Virginia Peninsula.

The tailoring of this information specifically to the Peninsula area allows guidance personnel and instructors to get a clearer view of the occupational cluster as it is characterized locally. In addition, it gives students, who are privy to the information, a more indepth look of the career field in one document.

VPVTC

FORECAST OF OCCUPATIONAL DEMAND
for the Virginia Peninsula
on

ELECTRONICS/ELECTROMECHANICAL TECHNOLOGY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2.20V
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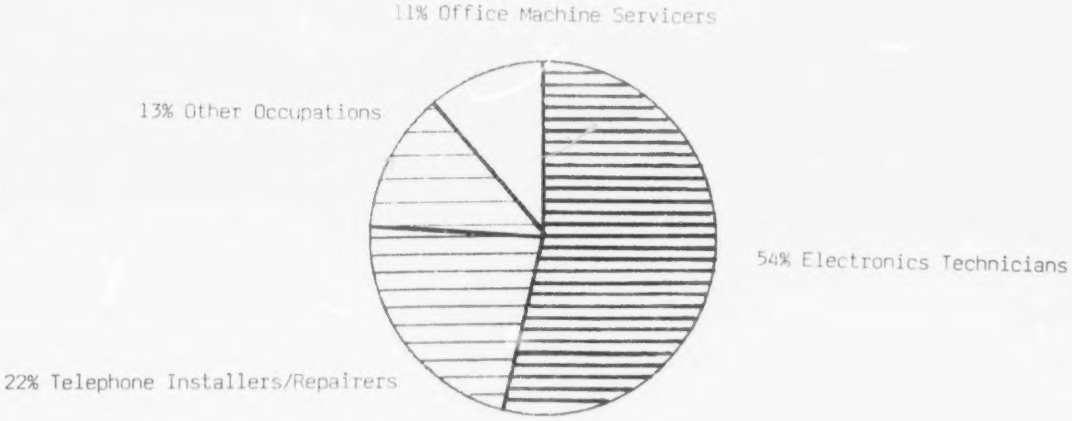
1.80V

NATURE OF THE OCCUPATION

This occupational cluster includes jobs with the following titles:

Title	DOT Code
Biomedical Equipment Technician	*719.261-010*
Calibration Laboratory Technician	*019.281-010*
Central Office Repairer	*822.281-014*
Electrical Instrument Repairer	*729.281-026*
Electric Motor Repairer	*721.281-018*
Electromedical Equipment Repairer	*729.281-030*
Electromechanical Technician	*710.281-018*
Electronic Production Mechanic	*629.281-022*
Electronic Sales and Service Technician	*828.251-010*
Electronics Assembler	*726.684-018*
Electronics Inspector	*726.381-010*
Electronics Mechanic	*828.281-010*
Electronics Technician	*003.161-014*
Electronics Tester	*726.281-014*
Electronics Worker	*726.687-010*
Instrumentation Technician	*003.261-010*
Instrument Mechanic	*710.281-026*
Laser Technician	*019.181-010*
Office Machine Servicer	*633.281-018*
Television and Radio Repairer	*720.281-018*
Telephone Maintenance Mechanic	*822.261-018*

The following chart shows the percentages of workers involved in each area of the occupation.



FORECAST OF OCCUPATIONAL DEMAND

There are two distinct levels of proficiency within this cluster:

1) The electronics technician must be able to assemble, install, test, adjust, maintain, service, and repair electronics equipment such as computers, office equipment, industrial control devices, electronic medical instruments, navigational equipment, radar, sonar, radios, televisions, telephones, and related communications equipment.

2) The master technician must be able to function in the modern world of complex systems and devices which requires special skills in the area of production, testing, installation, and maintenance. To perform these functions, special systems-oriented competencies in a combination of electrical, electronic, mechanical, fluids, pneumatic, optic, and thermal applications are required.

Knowledge of science, mathematics, and electrical and electronic equipment enables electronics/electromechanical technicians to work in any phase of business and government - - from research and design to manufacturing, sales, and customer service. Although their jobs are more limited in scope and more practically oriented than those of engineers or scientists, electronics/electromechanical technicians often apply the theoretical knowledge developed by engineers and scientists to actual situations. Because the field is so broad, electronics/electromechanical technicians often specialize in one area, such as automatic control devices or communications systems.

Working in design, production, or customer service, requires the use of sophisticated measuring and diagnostic devices to test, adjust, and repair equipment. Technicians must understand the purpose for which the electronic device is being used. Designing equipment for space exploration, for example, requires a technician to consider the need for minimum weight and volume and maximum resistance to shock, extreme temperature, and pressure.

Research and development is one of the largest areas of employment of electronic/electromechanical technicians. Here they set up experiments and equipment and calculate the results. They also assist engineers and scientists by making prototype versions of newly developed equipment and, frequently, by doing routine design work.

In production, technicians usually follow the general directions of engineers and scientists, but often function without any close supervision. They prepare specifications for components and devise and conduct tests to insure product quality. They may be required to supervise production workers to make sure they follow prescribed procedures.

As sales workers or field representatives for manufacturers, electronics/electromechanical technicians give advice on the installation and maintenance of complex equipment and write specifications and technical manuals.

OCCUPATIONAL DEMAND

In 1980 there were 1057 workers attached to this occupation employed on the Virginia Peninsula. At an estimated ten year growth rate of 27.1%, there should be 286 additional workers attached to the occupation by 1990.

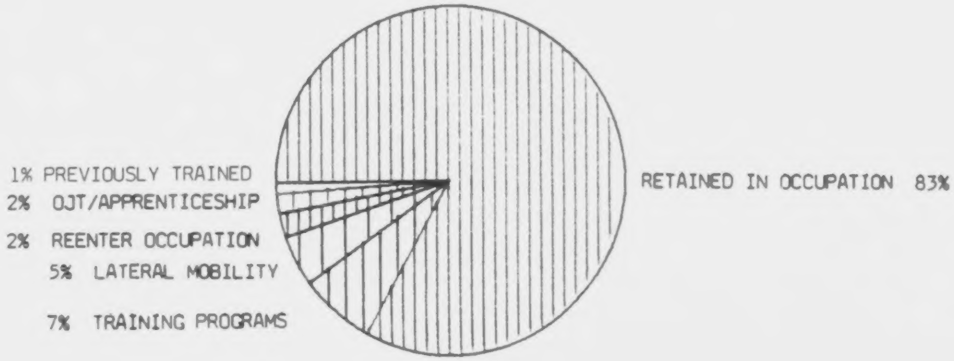
PROBABLE OCCUPATIONAL ATTACHMENT IN 1990. 1343

The average annual retention rate for this occupation is approximately 83.4%; the attrition rate, 13.9%, and the growth rate 2.7%. With attrition of approximately 186, and growth of 36, the annual openings due to attrition and growth are 409.

PROBABLE GROSS ANNUAL OCCUPATIONAL DEMAND. 222

Historically, 1.8%, or 24, of this occupation's workers reenter the occupation annually from unemployment. Another 4.6%, or 62, enter this occupation annually by lateral mobility from another occupation. This occupation is such that lateral mobility is possible for previously trained workers and military veterans, however it is estimated that only 12 (less than 1%) of the transferees will originate from these sources. The occupation lends itself to apprenticeship and OJT and it is estimated that another 1.9%, or 25, lateral transferees will enter by this method. Therefore, a total of 123 lateral transferees enter the occupation from the sources listed above. This leaves 7.4%, or 99, of the annual demand to be met through institutional or job training programs.

PROBABLE ENTRY-LEVEL DEMAND NOT MET THROUGH LABOR MOBILITY. 99



FORECAST OF OCCUPATIONAL DEMAND

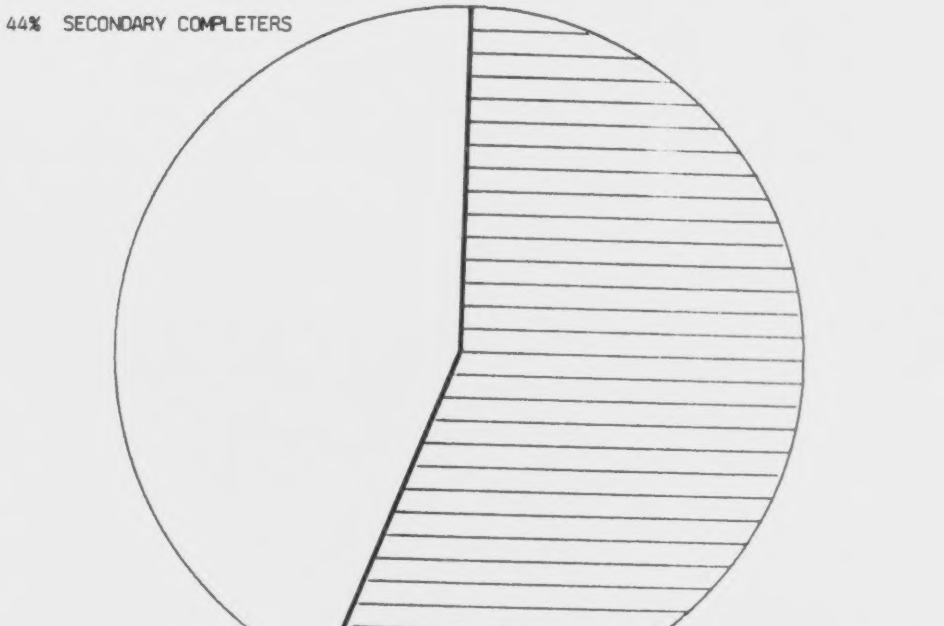
Historical enrollment and completion statistics indicate that over half of this occupation's institutionally-trained replacements train at the postsecondary level. Postsecondary institutions are, therefore, good sources for replacements.

PROBABLE ENTRY-LEVEL DEMAND OPEN TO POSTSECONDARY COMPLETERS. 55

The training required for this occupation is also extensive enough to warrant formal secondary-level course offerings and it is anticipated the remaining annual entry-level demand will be met by secondary-level vocational completers.

PROBABLE ENTRY-LEVEL DEMAND OPEN TO SECONDARY-LEVEL COMPLETERS. 44

The following chart transmits this data into a more quickly accessible form:



FORECAST OF OCCUPATIONAL DEMAND________________________________

CORE OCCUPATIONAL BASICS FOR

ELECTRONICS/ELECTROMECHANICAL TECHNOLOGY

1. READING - The student must demonstrate the ability to:

   - comprehend, interpret, and follow written directions, instructions, or specifications to include service manuals, technical publications, operational logs, reports, policies and procedures, blueprints, diagrams, visuals, and charts.

   - use publications to define words, research materials, identify and/or classify parts, and determine proper service or repair procedures for equipment, as well as to verify information.

2. WRITING - The student must demonstrate the ability to:

   - conceive, gather, select, organize, relate, and express information clearly and coherently in legible handwritten or printed form using the appropriate sentence structure, grammar, capitalization, and punctuation in a logical, coherent form.

   - quote, paraphrase, summarize, and cite sources accurately.

3. MATHEMATICS - The student must demonstrate the ability to:

   - select appropriate mathematical tools, (e.g., mental calculations, trial and error methods, manual techniques, calculators, and computers) to complete calculations, estimates, and measurements and apply them to solve problems.

   - support ideas quantitatively and/or statistically by using appropriate mathematical techiques to compile data.

   - apply mathematical processes to consumer economics to calculate costs (including related charges and taxes) and properly set up, maintain, and manage budgets.

   - add bills, receive various forms of payment, and make accurate change.

   - calculate addition, substraction, multiplication, and division using real numbers, decimals, fractions, integers, roots, and powers with reasonable accuracy.

   - express ratios, proportions, and percentages.

   - analyze, manipulate, and solve algebraic, fractional, polynomial, quadratic, logarithmic, and exponential equations.

3. MATHEMATICS (continued)

- apply right triangle trigonometry.
- solve basic geometric problems.
- perform fundamental operations with exponents and radicals.
- perform phasor operations.
- calculate distance, weight, area, volume, and time.
- use information from charts, graphs, and tables.
- calculate resources, time, and costs relevant to specific tasks.
- convert between traditional and metric systems.

4. SCIENCE - The student must demonstrate the ability to:

- apply scientific methodology by formulating and stating hypotheses and by evaluating them by observation or experimentation.
- recognize mechanical, physical, chemical, and biological problems and resolve them through the application of basic scientific principles.

5. SOCIOLOGY - The student must demonstrate the ability to:

- understand the people, ideals, ethics, politics (both domestic and foreign), and social issues which have shaped history.
- recognize social and cultural implications and follow accepted societal rules.

6. CIVICS - The student must demonstrate the ability to:

- understand the relationship between civic responsibilities and civic rights and entitlements.
- distinguishes between liberty and license.
- respect the need for statutory authority.

7. LISTENING AND SPEAKING - The student must demonstrate the ability to:

- understand the intent of spoken communication.
- ask and answer questions coherently to obtain, clarify, and verify information.

FORECAST OF OCCUPATIONAL DEMAND________________________________

7. LISTENING AND SPEAKING (continued)

- follow spoken instructions.
- take part in and interpret the exchange of ideas in discussions and participate objectively in them.
- report accurately what others have said.
- conceive, develop, and organize ideas about a subject and present them clearly in standard oral English.
- present oral reports and briefings accurately and succinctly in the language of electronics/electromechanical technology.
- give oral instructions in a manner which facilitates correct compliance.
- understand how spoken concepts and ideas can be distorted and how the accuracy and reliability of oral messages can be tested.
- recognize the effects of tone on voice, attitude, and body language on oral communication, and can vary these to obtain the desired results.
- use proper telephone protocol and procedures.
- exercise oral communication beyond mere spoken exchange to genuine understanding.

8. REASONING, PROBLEM SOLVING, AND DECISION MAKING - The student must demonstrate the ability to:

- gather and interrelate facts and input and sift through details to identify, conceptualize, and recognize the implications and significance of problems, and resolve them through analysis, conclusion, recommendations, and decisions.
- recognize the inconsistencies between the way things are and the way they should be and initiate problem solving techniques to resolve the situation.
- distinguishes among facts, assumptions, and opinions.
- understand the relationship between cause and effect.
- use inductive and deductive reasoning to include diagnosing and troubleshooting technical problems
- use decision making tools (e.g., risk and benefit criteria, development and description of alternatives, comparison, conclusions, and recommendations) to separate problems into manageable proportions.

FORCAST OF OCCUPATIONAL DEMAND

8. REASONING, PROBLEM SOLVING, AND DECISION MAKING (continued)

- relate knowledge, experience, and principles to new situations.
- change behaviors.
- evaluate, adapt, and develop logical steps to implement decisions.

9. INTERPERSONAL RELATIONSHIPS - The student must demonstrate the ability to:

- relate to and develop good working relationships with superiors and co-workers in an occupational role.
- demonstrate behaviors appropriate to and customary in the workplace.
- relate with peers in a social role.
- comprehend expectations of superiors, peers, and subordinates and take actions accordingly.
- understand the value and function of courtesy, compassion, fairness, humor, and positive attitude in human relationships.
- understand that progress in technology is a function of initiative, innovation, and trial-and-error experimentation, and that failure, as well as success, in experimentation, is to be regarded as an essential ingredient in progress.
- make temporary style changes to meet situational demands.
- deal with conflict or criticism in a rational, productive manner.
- manage interpersonal relationships in a negotiative mode rather than that of either authority or subservience.
- understand and be able to participate in the team concept.
- understand the destructiveness of stereotypical biases and prejudices on human relationships.
- understand the basis for the thoughts, feelings, motivations, and behavioral styles of others, and interact accordingly.

10. EMPLOYABILITY - The student must demonstrate the ability to:

- complete the procedures necessary to obtain employment to include filling out applications (both job and college), developing a resume, and preparing for a job interview.
- identify personal and technical skills and abilities and outline work objectives.

FORECAST OF OCCUPATIONAL DEMAND

10. EMPLOYABILITY (continued)

- comprehend the relationship between job specifications and personal characteristics and develop competencies to match the specifications.
- demonstrate motivational skills.
- exhibit techniques for coping with organizational change.
- understand the need for leadership roles within the work environment.
- understand the principles of competition within a work environment.
- understand the principles of compensation to include pay, benefits, perquisites, and intangibles.

11. ENTREPRENEURSHIP - The student must demonstrate the ability to:

- understand the fundamentals of capitalization, organization, management, productivity, profitability, risk, and competition as they apply to product or service businesses or enterprises.
- understand the basic economic system of the United States and its relationship to employment.
- understand the fundamentals of economics to include money, capital investment, risk, productivity, demand, and supply, competition, pricing, margin profit and loss.
- understand the distinction among corporations, partnerships, and proprietorships.
- understand the roles of business, industry, government, and labor in economic development and growth, maintaining employment, creating wealth, and raising the standard of living.
- comprehend the need for structure and organization in an enterprise.
- understand accountability for results.
- understand the unique role of experimentation in research and development in technological occupations.
- understand goals and objectives, functions and tasks, effectiveness versus efficiency, and the relationship among input, process, and output.

12. WORK ETHICS - The student must demonstrate the ability to:

- understand the essential relationship between supervisor and subordinate.

FORECAST OF OCCUPATIONAL DEMAND

12. WORK ETHICS (continuedO

- understand and respect the need for and function of organizational structure, supervision, authority, values, policies, procedures, rules, schedules, deadlines, and performance standards.
- accomplish assigned tasks with or without supervision.
- exercise initiative in the absence of instruction.
- interpret goals, make realistic plans, set priorities, and take action to meet them.
- demonstrate ingenuity in meeting challenges.
- concentrate on the job to be done.
- avoid easy discouragement, and exhibit perserverence in completing difficult tasks.
- take challenges in stride.
- perform reliably as an individual and as a cooperative team member.
- demonstrate integrity, honesty, loyalty, and respect for the values of the organization.
- exhibit a sense of pride in quality craftsmanship or service.
- maintain equipment and work stations in good order, and follow safety procedures explicitly.
- maintain dependable attendance and punctuality, and notify supervisor promptly of any impending tardiness or absence.
- cope with multiple roles and responsibilities, and balance personal and professional demands.
- exhibit enthusiasm and zeal, and demonstrates desire and willingness to learn and improve.
- distinguish between legitimate mistakes associated with initiative and trial and error, and errors of omission or commission associated with carelessness, inattentiveness, apathy, or incompetence, and respond appropriately and constructively.
- understand that organizational and individual growth is obtained through constructive criticism, and be objective about receiving criticism from supervisors and other employees.
- see each individual as a part of a whole which accomplishes the productivity, and self-evaluate personal contribution to the team effort.

12. WORK ETHICS (continued)

- neither underestimate nor overestimate personal value or self importance to the total operation.
- maintain standards of appearance, dress, grooming, and personal hygiene appropriate to the nature of the electronics/electromechanical occupation.
- maintain levels of nutrition, health, and physical conditioning appropriate to the occupation, to include avoidance of substance abuse, and cope effectively with the stresses and strains peculiar to the occupation.
- accept and seek out responsibility.
- understand the meaning of "work" and the significance of "a day's work for a day's pay."

13. ADAPTABILITY - The ability to:

- possess the self-confidence to regard change as a natural ingredient of progress which is not to be feared, but rather viewed as an opportunity for improvement.
- adjust to changes in job assignments, systems, procedures, schedules, policies, and supervisors.
- learn alternate and more difficult skills in anticipation of lateral or upward mobility.
- adapt to structural changes in the workforce.
- possess the self-discipline to engage in self-study or self-improvement away from the formality of the classroom.
- maintain the capability and credentials to reenroll in education and training programs to upgrade job skills to stay current with requirements.
- keep abreast of changes within the electronics/electromechanical technology occupation.

FORECAST OF OCCUPATIONAL DEMAND

ENTRY-LEVEL OCCUPATIONAL COMPETENCIES FOR

ELECTRONICS/ELECTROMECHANICAL TECHNOLOGY

The following is a listing of competencies compiled from a variety of sources and through DACUM workshops with local business/industry/government experts in the occupational field of electronics/electromechanical technology. This listing has been validated through the DACUM process and is appropriate for use in curriculum development.

COMMUNICATING TECHNICAL INFORMATION

Identify schematic symbols for electronic components without significant error.

Interpret mechanical blueprints without significant error

Prepare mechanical drawings according to given specifications.

Prepare assembly drawings according to given specifications.

Prepare electronic drawings according to given specifications.

Prepare pictorial drawings according to given specifications.

Interpret blueprint scales without significant error.

Prepare a wire routing sheet according to given specifications.

Translate charts and graphs without significant error.

Use manufacturer's service literature and parts catalogs to successfully find the material(s) needed, and instructions for, making repairs to malfunctioning equipment.

DEMONSTRATING FABRICATION TECHNIQUES

Demonstrate accepted soldering techniques according to given specifications.

Make wire wrap corrections according to given specifications.

Construct a wire harness (interface) according to given specifications.

Prepare shielded wire/coaxial cables for installation according to specifications.

Construct a P.C. board according to given specifications.

Install components on a P.C. board according to given specifications.

Demonstrate proper handling techniques for MOSFETS.

Construct a chassis according to given specifications.

FORECAST OF OCCUPATIONAL DEMAND

ENTRY-LEVEL OCCUPATIONAL COMPETENCIES FOR

ELECTRONICS/ELECTROMECHANICAL TECHNOLOGY

DEMONSTRATING D.C. KNOWLEDGE

Identify parts of the atom without significant error.

Identify conductors, insulators, and semiconductors without significant error.

Identify resistors without significant error.

Use Ohm's law formula according to given specifications.

Measure resistive current and voltage drop in D.C. resistive circuits without significant error.

Analyze the relationship between R and I in a resistor according to given specifications.

Identify series circuit characteristics without significant error.

Identify parallel circuit characteristics without significant error.

Identify series parallel circuit characteristics without significant error.

Identify types of batteries without significant error.

Analyze loaded and unloaded resistive voltage divider circuits according to given specifications.

Analyze D.C. circuits using Kirchoff's Law.

Analyze D.C. circuits using the superposition thereom.

Use Thevinin's and Norton's theorems according to given specifications.

Use Millman's theorem according to given specifications.

Analyze bridge circuits according to given specifications.

Demonstrate the laws of magnetism according to given specifications.

Explain magnetic hysteresis without significant error.

Determine the magnetic polarity of a solenoid according to given specifications.

DEMONSTRATING A.C. KNOWLEDGE

Define the characteristics of A.C. without significant error.

Calculate current ratio according to given specifications.

ENTRY-LEVEL OCCUPATIONAL COMPETENCIES FOR
ELECTRONICS/ELECTROMECHANICAL TECHNOLOGY

DEMONSTRATING A.C. KNOWLEDGE (continued)

Calculate inductive reactance according to given specifications.

Calculate the phase angle in RL circuits according to given specifications.

Calculate total capacitance according to given specifications.

Calculate capacitive reactance according to given specifications.

Calculate circuit parameters for an RC time constant according to specifications.

Calculate RC and LR time contant according to given specifications.

Calculate impedance or RLC circuits according to given specifications.

Apply complex numbers to A.C. circuit calculations according to given specifications.

Compute Kirchoff's laws for network analysis of A.C. circuits according to given specifications.

Compute V Thevinin and I Norton for network analysis of A.C. circuits according to given specifications.

Analyze series and parallel resonant circuits according to given specifications.

Analyze filter circuits according to given specifications.

WORKING WITH AMPLIFIERS, OSCILLATORS, AND POWER SUPPLIES

Explain the operation of a PN junction diode without significant error.

Graph the voltampere characteristics of a zener diode according to given specifications.

Design a seven-segment display circuit according to given specifications.

Construct a half wave rectifier circuit according to given specifications.

Construct a full wave rectifier circuit according to given specifications.

Construct a voltage regulator circuit according to given specifications.

Explain the operation of junction transistors without significant error.

Design a voltage divider bias circuit according to given specifications.

Design a common emmitter (CE) amplifier according to given specifications.

ENTRY-LEVEL OCCUPATIONAL COMPETENCIES FOR

ELECTRONICS/ELECTROMECHANICAL TECHNOLOGY

WORKING WITH AMPLIFIERS, OSCILLATORS, AND POWER SUPPLIES (continued)

Design and construct common collector (CC) amplifiers according to specifications.

Calculate circuit charactersitics using H parameters without significant error.

Design a class A amplifier according to given specifications.

Analyze class B push-pull emitter follower amplifiers according to given specifications.

Analyze tuned class C amplifiers according to given specifications.

Construct a voltage regulator circuit according to given specifications.

Analyze the operation of a JFET circuit according to given specifications.

Analyze a MOSFET circuit according to given specifications.

Analyze the frequency response of an AC amplifier according to given specifications.

Calculate decibel power gain and decibel voltage gain without significant error.

Construct an IC regulated power supply according to given specifications.

Design a Wien-bridge oscillator according to given specifications.

Draw the I-V characteristic of an SCR without significant error.

Analyze the operation of a triode vacuum tube amplifier according to given specifications.

FORECAST OF OCCUPATIONAL DEMAND ____________________

ADVANCED-LEVEL OCCUPATIONAL COMPETENCIES FOR

ELECTRONICS/ELECTROMECHANICAL TECHNOLOGY

The following is a listing of competencies compiled from a variety of sources and through DACUM workshops with local business/industry/government experts in the occupational field of electronics/electromechanical technology. This listing has been validated through the DACUM process and is appropriate for use in curriculum development.

DEMONSTRATING KNOWLEDGE OF OPERATIONAL AMPS WITH IC APPLICATIONS

Design and analyze single-ended amplifiers using op amps.

Design and analyze differential amplifiers using op amps.

Design and analyze instrumentation amplifiers according to given specifications.

Design an analyze integrators and differentiators according to given specifications.

Describe and analyze the working principles of PLL according to given specifications.

Analyze and describe the working principles of voltage regulators according to given specifications.

Analyze and describe the working principles of oscillators according to given specifications.

Analyze and describe the working principles of integrated circuits according to given specifications.

USING TEST INSTRUMENTS

Identify and explain the use of various test instruments without significant error.

Demonstrate the function of each control on various measuring instruments without significant error.

Explain loading effects of measuring instruments without significant error.

Match impedance according to given specifications.

Calibrate test equipment according to given specifications.

Measure various electrical parameters according to given specifications.

Demonstrate a knowledge of instrumentation techniques according to given specifications.

Demonstrate a knowledge of measurement instruments according to given specifications.

ADVANCED-LEVEL OCCUPATIONAL COMPETENCIES FOR

ELECTRONICS/ELECTROMECHANICAL TECHNOLOGY

USING TEST INSTRUMENTS (continued)

Demonstrate a knowledge of various instrumentation terms according to given specifications.

Demonstrate an understanding of measurement principles according to given specifications.

DEMONSTRATING DIGITAL KNOWLEDGE

Demonstrate a knowledge of symbolic logic according to given specifications.

Demonstrate understanding of commonly used logic blocks according to given specifications.

Design encoders, decoders, counters, registers, and arithmetic circuits according to given specifications.

Calibrate timing/clock pulse frequency and amplitude.

Demonstrate basic knowledge of A to D and D to A converters according to given specifications.

Analyze computer system building blocks according to given specifications.

Demonstrate a basic knowledge of digital data transmission according to given specifications.

Calibrate multivibrator circuits according to given specifications.

Construct a digital logic circuit according to given specifications.

Explain the limitations of some test equipment without significant error.

Explain the basic parts of a computer and describe their functions without significant error.

Demonstrate elementary programming concepts according to given specifications.

Demonstrate a knowledge of various interfacing techniques according to given specifications.

Demonstrate a knowledge of configurations of systems according to given specifications.

Interface a digital circuit to a microprocessor according to given specifications.

Analyze logic family interfaces according to given specifications.

FORECAST OF OCCUPATIONAL DEMAND ______________________________

ADVANCED-LEVEL OCCUPATIONAL COMPETENCIES FOR

ELECTRONICS/ELECTROMECHANICAL TECHNOLOGY

DEMONSTRATING DIGITAL KNOWLEDGE (continued)

Analyze microprocessor functions according to given specifications.

WORKING WITH MOTORS

Demonstrate an understanding of magnetic fields and their applications according to given specifications.

Demonstrate a knowledge of D.C. motors and generators and their applications according to given specifications.

Demonstrate a knowledge of A.C. motors and alternators and their applications according to given specifications.

Demonstrate competence in single-phase power circuits and systems according to given specifications.

Demonstrate competence with three-phase power circuits according to given specifications.

Demonstrate competence in fractional horse power motors and their applications according to given specifications.

Demonstrate competence in power transformers according to given specifications.

Demonstrate basic troubleshooting techniques according to given specifications.

Properly measure and test electrical machines according to given specifications.

WORKING WITH COMMUNICATION DEVICES

Analyze analog multiplexing circuits according to given specifications.

Analyze AM and FM demodulator circuits according to given specifications.

Analyze amplitude AM modulator circuits according to given specifications.

Analyze frequency FM modulator circuits according to given specifications.

Analyze remote control circuits according to given specifications.

Analyze transmission interface systems according to given specifications.

Identify electrical characteristics of frequency modulators without significant error.

ADVANCED-LEVEL OCCUPATIONAL COMPETENCIES FOR

ELECTRONICS/ELECTROMECHANICAL TECHNOLOGY

WORKING WITH COMMUNICATIONS DEVICES (continued)

Identify electrical characteristics of amplitude modulators according to given specifications.

Identify terms to describe operational characteristics of sound IF and AM without significant error.

Identify terms to describe operational characteristics of video amplifiers without significant error.

Identify terms to describe operational characteristics of UHF tuner circuits without significant error.

Identify terms to describe operational characteristics of remote controls without significant error.

Identify terms to describe operational characteristics of auto gain control without significant error.

Identify terms to describe operational characteristics of auto frequency control without significant error.

Identify terms to describe operational characteristics of noise cancelling without significant error.

Identify terms to describe operational characteristics of phase lock loop without significant error.

Demonstrate knowledge of principles of generation, coupling, and amplification according to given specifications.

Demonstrate knowledge of principles of modulation according to given specifications.

WORKING WITH MICROWAVE COMMUNICATIONS

Demonstrate a knowledge of microwave theory according to given specifications.

Demonstrate an understanding of measurement techniques for certain fields according to given specifications.

Demonstrate an understanding of transmission lines according to given specifications.

Demonstrate a knowledge of and the use for the Smith Chart according to given specifications.

Demonstrate how to determine the impedance and admittance according to given specifications.

FORECAST OF OCCUPATIONAL DEMAND

ADVANCED-LEVEL OCCUPATIONAL COMPETENCIES FOR

ELECTRONICS/ELECTROMECHANICAL TECHNOLOGY

WORKING WITH MICROWAVE COMMUNICATIONS (continued)

Demonstrate impedance matching by using stubs.

Demonstrate how to measure standing wave ratios of transmission according to given specifications.

Demonstrate a knowledge of resonance cavaties according to given specifications.

Demonstrate how to measure microwave frequency according to given specifications.

Demonstrate a knowledge of microwave antennas, microwave systems, and multiplexing according to given specfications.

Demonstrate a knowledge of fiber optics according to given specifications.

Identify various types of microwave generators, oscillators, and detectors without significant error.

USING MATERIALS AND PROCESSES OF INDUSTRY

Demonstrate a knowledge of the nature of materials according to given specifications.

Demonstrate a knowledge of the atomic structure of materials according to given specifications.

Demonstrate a knowledge of the properties of materials according to given specifications.

Demonstrate a knowledge of the testing of materials according to given specifications.

Demonstrate a knowledge of metallic materials according to given specifications.

Demonstrate a knowledge of polymeric materials according to given specifications.

Demonstrate a knowledge of ceramic materials according to given specifications.

Demonstrate a knowledge of composite materials according to given specifications.

Demonstrate a knowledge of the testing of materials according to given specification specifications.

WORKING WITH FLUID POWER SYSTEMS

Demonstrate a knowledge of hydraulic power systems according to given specifications.

Demonstrate a knowledge of pneumatic power systems according to given specifications.

FORECAST OF OCCUPATIONAL DEMAND____

ADVANCED-LEVEL OCCUPATIONAL COMPETENCIES FOR

ELECTRONICS/ELECTROMECHANICAL TECHNOLOGY

WORKING WITH FLUID POWER SYSTEMS (continued)

Demonstrate a knowledge of fluid power systems according to given specifications.

Demonstrate a knowledge of hydraulic and pneumatic applications according to given specifications.

Demonstrate an understanding of liquid and gas properties according to given specifications.

Demonstrate a knowledge of hydraulic and pneumatic symbols and circuits according to given specifications.

Demonstrate an understanding of the operation of pumps according to given specifications.

Demonstrate an understanding of the operation of actuators according to given specifications.

Demonstrate an understanding of the operation of valves according to given specifications.

Demonstrate an understanding of the operation of hydraulic fluids according to given specifications.

Demonstrate a knowledge of the operations of reservoirs according to given specifications.

Demonstrate a knowledge of testing procedures for hydraulic systems according to given specifications.

Demonstrate aknowledge of testing procedures for pneumatic systems according to given specifications.

Demonstrate basic troubleshooting techniques for fluid power systems according to given specifications.

WORKING WITH COMPUTERS

Demonstrate a knowledge of machine language programming according to given specifications.

Demonstrate a knowledge of logic symbols and logic diagrams according to given specifications.

Demonstrate a knowledge of integrated wiring diagrams according to given specifications.

FORECAST OF OCCUPATIONAL DEMAND ____________________

ADVANCED-LEVEL OCCUPATIONAL COMPETENCIES FOR

ELECTRONICS/ELECTROMECHANICAL TECHNOLOGY

WORKING WITH COMPUTERS (continued)

Demonstrate a knowledge of input-output devices according to given specifications.

Demonstrate a knowledge of memory devices according to given specifications.

Demonstrate a knowledge of booleans algebra and basic logic design techniques according to given specifications.

Demonstrate a knowledge of logic timing circuits according to given specifications.

Demonstrate a knowledge of basic test equipment used for digital systems according to given specifications.

Demonstrate the troubleshooting technqiues used for digital systems according to given specifications.

WORKING WITH LASERS AND FIBER OPTICS

Demonstrate a knowledge of optocomponents circuit symbols without significant error.

Demonstrate a knowledge of various types of laser optics and their applications without significant error.

Demonstrate a knowledge of techniques used in troubleshooting optoelectronics according to given specifications.

Demonstrate a knowledge of assembling and testing optotype circuits according to given specifications.

Demonstrate a knowledge of the safety precautions needed to maintain lasers according to given specifications.

Measure voltage, waveshape, phase shift-distraction, and phometric power according to given specifications.

Demonstrate a knowledge of the techniques used in handling sensitive components according to given specifications.

Demonstrate a knowledge for fiber optic transceivers and transmitters, and their use, according to given specifications.

Demonstrate a knowledge of various types of power lasers according to given specifications.

Demonstrate a knowledge of the maintenance and repair of lasers according to given specifications.

Demonstrate a knowledge of cutting/splicing fiber-optic components according to given specifications.

FORECAST OF OCCUPATIONAL DEMAND________________________

ADVANCED-LEVEL OCCUPATIONAL COMPETENCIES FOR

ELECTRONICS/ELECTROMECHANICAL TECHNOLOGY

WORKING WITH ELECTRONIC CONTROL SYSTEMS

Identify transducers without significant error.

Identify servos and selsyns without significant error.

Measure vibrations according to given specifications.

Record the ability of electronic circuits and modules to withstand impacts according to given specifications.

Demonstrate a knowledge of controllers according to given specifications.

Analyze control systems according to given specifications.

Demonstrate a knowledge of process characteristics according to given specifications.

Demonstrate a knowledge of control characteristics according to given specifications.

Explain open and closed loop stability without significant error.

Demonstrate a knowledge of basic theory of several types of controls according to given specifications.

Demonstrate a knowledge of system control components according to given specifications.

Demonstrate a knowledge of microcomputers and analog computers used in controls according to given specifications.

Demonstrate a knowledge of component characteristics according to given specifications.

Demonstrate a knowledge of transducers and their calibration according to given specifications.

Demonstrate a knowledge of servomechanisms according to given specifications.

Demonstrate a knowledge of the process controls according to given specifications.

WORKING WITH ROBOTICS

Demonstrate a knowledge of programming, software, teach modes, and diagnostic routines for robotics according to given specifications.

Demonstrate a knowledge of fluid power logic diagrams according to given specifications.

FORECAST OF OCCUPATIONAL DEMAND____

ADVANCED/LEVEL OCCUPATIONAL COMPETENCIES FOR

ELECTORNICS/ELECTROMECHANICAL TECHNOLOGY

WORKING WITH ROBOTICS (continued)

Demonstrate a knowledge of the theory of operations of controls for robotics according to given specifications.

Demonstrate a knowledge of several types of sensors and their applications according to given specifications.

Demonstrate a knowledge of several types of hydraulic and pneumatic pumps according to given specifications.

Demonstrate a knowledge of the maintenance and calibration of several robots according to given specifications.

Demonstrate a knowledge of diagnostic routines according to given specifications.

Demonstrate a knowledge of system troubleshooting according to given specifications.

Demonstrate a knowledge of test equipment for robotics according to given specifications.

Demonstrate a knowledge of safety practices in maintaining robots without significant error.

DEMONSTRATING A KNOWLEDGE OF STRENGTHS OF MATERIALS

Demonstrate a knowledge of force systems according to given specifications.

Demonstrate a knowledge of centroids and moments of inertia according to given specifications.

Demonstrate a knowledge of friction according to given specifications.

Demonstrate a knowledge of equilibrium according to given specifications.

Demonstrate a knowledge of force analysis of structures according to given specifications.

Demonstrate a knowledge of stress and strain according to given specifications.

Demonstrate a knowledge of torsion according to given specifications.

Demonstrate a knowledge of shear force and bending movements according to given specifications.

Demonstrate a knowledge of streeses in beams according to given specifications.

Demonstrate a knowledge of combined stresses according to given specifications.

FORECAST OF OCCUPATIONAL DEMAND ____________________________

ADVANCED-LEVEL OCCUPATIONAL COMPETENCIES FOR

ELECTRONICS/ELECTROMECHANICAL TECHNOLOGY

DEMONSTRATING A KNOWLEDGE OF DYNAMICS

Apply laws of motion to solve for unknown components of motion according to given specifications.

Solve problems for unknowns in concurrent force systems by the force method.

Solve problems for unknowns in nonconcurrent force systems by the force method.

Solve problems for unknowns by applying principles of centrifugal inertia force.

Solve problems involving relations between linear and angular motion according to given specifications.

Solve problems applying the force method to place the body in equilibrium.

Solve for problems applying principles of forces and moments of various reference axis.

Solve for problem unknowns by application of the work-force method.

Solve for problems applying principles involved in impuse, momentum, and impact according to given specifications.

DEMONSTRATING A KNOWLEDGE OF ELECTROMECHANICAL SYSTEMS

Demonstrate a knowledge of electromechanisms used as blocks for systems according to given specifications.

Demonstrate a knowledge of maintenance programs according to given specifications.

Demonstrate a knowledge of tools and equipment for servicing systems without significant error.

Demonstrate a knowledge of the safety precautions in servicing systems without significant error.

Demonstrate a knowledge of operational amplifiers for industrial applications according to given specifications.

Demonstrate a knowledge of linear integrated circuits for industrial applications according to given specifications.

Demonstrate a knowledge of electromechanical control systems according to given specifications.

Develop a maintenance record according to given specifications.

FORECAST OF OCCUPATIONAL DEMAND____

ADVANCED-LEVEL OCCUPATIONAL COMPETENCIES FOR

ELECTRONICS/ELECTROMECHANICAL TECHNOLOGY

DEMONSTRATING A KNOWLEDGE OF ELECTROMECHANICAL SYSTEMS

Inspect mechanical and electrical drive systems finding all major malfunctions.

Note repairs which can't be repaired in-house; make necessary arrangements for repairs.

Demonstrate a knowledge of industrial control devices according to given specifications.

Demonstrate a knowledge of power control circuits according to given specifications.

Demonstrate a knowledge of transducers according to given specifications.

Demonstrate aknowledge of the characteristics of operations for industrial processes according to given specifications.

Demonstrate a knowledge of sequential process controls according to given specifications.

OCCUPATIONAL EQUIPMENT, TOOLS, AND WORK AIDS FOR ELECTRONICS/ELECTROMECHANICAL TECHNOLOGY

EQUIPMENT

AC/DC rotating machines
Adapter cables
Air compressor
Antennas
Assorted bridges (AC, DC, Whetstone)
Assorted generators (e.g., AC, audio, current, DC, function, noise, measurement, pulse, resistive, signal, sweep, transient response, time, voltage, audio frequency, marker adder, RF)
Assorted hammers (standard, ballpeen, electrician)
Assorted meters (e.g., ammeter, display, decibel, digital multimeter, field strength, grid dip, ohmmeter, power, Q-meter, Z-meter, voltmeter, galvanometer)
Assorted motors
Assorted oscilloscopes (e.g., dual trace, single trace, storage)
Assorted probes (e.g., amp, high frequency, logic, RF)
Assorted testers (e.g., CRT, impedance, insulation, microwave, transducer, tube, vacuum)
Battery eliminator
Bench model drill press
Bias box
Braces
Capacitor checkers
Digital analyzer
Digital display oscilloscope
Digital voltmeter instruments
Earphones and microphone headset
Electrical voltmeter instruments
Face shield
First aid kit
Grinder
Hardhat
Holding device
Lathes
Logic analyzer clips
Machinist swivel base table vise
Magnifying bench lamp
Mechanical drive system
Meger
Pot solder
Power source
Power supplies
Resistor/capacitor decade box
Resistance test instruments
Scales (eningeering, metric, English)
Selsyns
Servos

FORECAST OF OCCUPATIONAL DEMAND ______________________________

OCCUPATIONAL EQUIPMENT, TOOLS, AND WORK AIDS FOR ELECTRONICS/ELECTROMECHANICAL TECHNOLOGY

EQUIPMENT

Sheet metal brakes
Stool
Tape reader
Transformers
Transmitter
Transistor curve tracer
V-blocks
Vacuum cleaner
Vector board and clip
Voltage test instruments
Wire harness
Work bench X-Y recorder

TOOLS

Alignment tools
Angle plates
Assorted tubes (e.g., pentode, tetrode, triode, vacuum)
Assorted chisels (e.g., cold set, wood)
Assorted crimping devices (e.g., terminal)
Assorted bits (e.g., drill, auger, expansion, flatwood, wood drill)
Assorted measuring devices (e.g., calipers, scales, micrometer calipers, rules)
Assorted pliers (longnose, diagnol, combination, lineman)
Assorted saws (e.g., hack, jig, hand, key hole, hole)
Assorted screwdrivers (e.g., swivel, phillips, standard)
Assorted snips (e.g., tin)
Assorted soldering tools
Assorted strippers (e.g., cable, wire, Romex)
Assorted wire mess cable pullers
Assorted wrenches (e.g., metric, metric socket, standard socket, standard, Allen)
Desoldering tool
Dewrapping tool
Diagonal cutters
Elbows (30,45,60,90)
Electricians knife
Electricians tap and die set
Exacto knife set
File set
Frequency counter
IC extractor/insertion set
Layout devices
Magnent
Magnifying glass

OCCUPATIONAL EQUIPMENT, TOOLS, AND WORK AIDS FOR ELECTRONICS/ELECTROMECHANICAL TECHNOLOGY

TOOLS

Nibbling tools
Nutdriver set
Oil can
Pipe and tube cutter
Plumb bob
Punch set
Reamer
Rivet gun
Safety glasses
Scribes
Shears
Small mirrors
Soldering appliances
Soldering stands
T-square
Test leads
Triangles (30-60 & 45-90)
Tube puller
Tube pin straightner
Tweezers
Wire brush
Wire gage
Wire strippers
Wire ties
Wire wrap gun
Wire wrap terminals
Wire wrap tools

WORK AIDES

Adhesives
Assorted bolts
Assorted capacitors
Assorted chips (e.g., IC, integrated circuit)
Assorted clamps
Assorted coils
Assorted connectors
Assorted diodes
Assorted fittings
Assorted nails
Assorted nuts
Assorted resistors
Assorted screws
Assorted transducers (e.g., industrial, light, pressure, temperature)

FORECAST OF OCCUPATIONAL DEMAND

OCCUPATIONAL EQUIPMENT, TOOLS, AND WORK AIDS FOR ELECTRONICS/ELECTROMECHANICAL TECHNOLOGY

WORK AIDS

Assorted transformers
Assorted tubes (e.g., pentode, tetrode, triode, vacuum)
Assorted tubings
Assorted vacuum tubes
Assorted washers
Assorted wires
ANSI standards
Blueprints
Body grounding strap
Cable (coaxial & shielded)
Calibrator crystal
Component outlines
Connector patterns
Chassis
Circle template
Circuit chiller
Daul-in-line-package
Desoldering wick
Digital display devices
Diodes
Dip pads
Display device
Donuts
Drawings (point to point, highway, baseline, straightline)
Drive gears
Electrical schematics
Engineering drawing symbols chart
Epoxy
Exploded view of assembly
Extension cords
Flacpac terminals
Flat stock
Full scale mechanical layout
Graph paper
Grid paper (0.5 per ", 0.100 per ", 0.125 per ")
Heat sinks
Inductors
Integrated circuits
Layout templates
Leads
Logarthmic paper
Lubrication oil
MOSFETS
MOSFETS block diagram symbols chart
MPUs
Mechanical drawings

OCCUPATIONAL EQUIPMENT, TOOLS, AND WORK AIDS FOR ELECTRONICS/ELECTROMECHANICAL TECHNOLOGY

WORK AIDS

Military standards
NASA wire wrap and soldering standards
Oil
PC boards
Phono plugs
Potting compound
Radio chassis
Rectifiers
Routing table information
Samples of lacing material
Schematic diagrams
Sheet stock
Silicon compound lubricant
Solder
Solderless splices
Solid state memories
Tape (1/16" to 18")
Terminal pads
Tracing paper
Transistor pads
Triangles
Vacuum tube sockets
Wall chart of electrical symbols
Waxed string
White print
Wiping rags
Wire (solid, stranded, cable, coaxial, ribbon, shielded)
Wire coding chart

WORKING CONDITIONS

Electronics/electromechanical technicians work in a relatively flexible organization in which they interact freely with other technicians, managers, supervisors, engineers, and trade workers. In larger organizations, they generally work under the supervision of experienced engineers. In some smaller organizations, they work directly with or for management. In either case, these technicians usually work with a minimum of supervision. Some work outside is required for performing installation or maintenance. There is seldom any prolonged exposure to heat, cold, or dampness; noise or vibration; fumes, odors, toxic conditions, dust, or poor ventilation. On ocassion, some technicians may be exposed to electric shock hazards from equipment.

Co-workers usually include other electronics/electromechanical technicians or equivalents from other occupations, although the nature of the occupation does tend to cut across many of the lines typical of more highly structured occupations.

ATTITUDES AND BEHAVIORS

Employees who demonstrate a skill for solving problems about techniques, processes, procedures, and electromechanical systems are good candidates for this occupation. Satisfaction is derived from recognizing and expressing electronic and electromechanical phenomena. Electronics/electromechanical technicians must be meticulous and have the patience to accomplish tasks in an orderly fashion according to set standards and procedures.

These technicians may work for degreed engineers with more education and frequently more experience. They may also be the intermediaries between engineers and lesser skilled workers. Accordingly, these technicians must be able to play multi-level roles dealing with the relationships and dependencies between supervisors and subordinates. The nature of the occupation demands that these technicians recognize the capabilities and limitations of their supervisors, subordinates, and themselves as well as the relationship among the three. They must be able to resolve technical chanllenges and fill voids or needs for assistance under these conditions. In particular, these technicians must be sensitive to the needs and techniques for receiving and sharing knowledge, vertically and laterally. They must also be able to recognize how new developments impact upon the limitations of others.

Electronics/Electromechanical technicians must understand that the knowledge and competency foundation of this occupation is likely to change rapidly as new technology takes shape. They must have the desire to maintain currency in their chosen field.

Technicians in this occupation must also be adept at managing time and must enjoy working responsibly alone or with minimum supervision, while keeping others informed of their progress.

Most electronics/electromechanical technicians work on or around products or provide services with which pride in technical accomplishment is associated. They must exude pride in their work and must display institutional pride to customers and clients. Since pride of this nature is difficult to generate without genuine feelings, they must be of the type who derive satisfaction and pride through the sound application of technical principles and techniques, and not necessarily through success alone, especially in the experimentation process. Electronics/electromechanical technicians must be curious and inquisitive and must derive genuine satisfaction from uncovering and revealing answers to technical problems.

FORECAST OF OCCUPATIONAL DEMAND

MENTAL AND PHYSICAL REQUIREMENTS

THE FOLLOWING ARE AVERAGE ON A SCALE OF 1 TO 6 WITH 1 BEING THE LOWEST AND 6 BEING THE HIGHEST.

The mental requirements for electronics/electromechanical technicians are roughly mid-way on the scale between degreed professionals and upper-scale skilled workers.

Mathematical ability for individuals in the electronics/electromechanical technology occupation ranges from 3 at the electronics worker level to 4 at the technician level. Electronics workers should be proficient at shop math and able to calculate area, volume, weight, and measure proportions and percentages. They should also be able to calculate unknowns through algebra and comprehend geometric properties. In addition, electronics/electromechanical technicians must be able to deal with linear, quadratic, rational, exponential, logarithmic, and like functions as well as algebraic solutions of equations and inequalities, probabilities, and statistical inference. They must also be proficient in both plane and solid geometry.

Language ability for these individuals ranges from 2 at the lower skill levels to 4 at the higher skill levels, with a mean of 3.1 and a medium and mode of 3. Electronics workers must be able to read magazines and instructions in the use of shop tools and equipment, safety, and methods and procedures in mechanical drawing and layout work. They must be able to write simple reports and execute paperwork associated with electronic servicing. They must be able to speak comfortably with supervisors, peers, and customers. Electronics/electromechanical technicians must be able to read periodicals, journals, manuals, dictionaries, and encyclopedias in addition to technical materials. They must be able to prepare detailed reports and summaries using prescribed formats and adhering to conventional rules of grammar and style. They must be able to participate in discussions and reviews, and must be able to speak extemporaneously on job-related matters.

Physically, the strength required in this occupation varies from light to medium, depending upon the specific job. A technician may sit or stand, and may be required to lift, carry, and push or pull objects weighing up to 20 pounds. Those in communications installation or maintenance may be required to handle heavier objects, and may have to perform climbing and balancing. Almost all jobs in the occupation require extending the hands in all directions; grasping, seizing, holding, turning, and otherwise handling objects; picking, pinching, rotating, or otherwise fingering objects; and using the sense of feel, particularly in the fingertips, to determine texture, size, shape, or temperature of objects. A few jobs require the worker to stoop, kneel, crouch, or crawl, but the mainstream jobs require very little of these physical capabilities. Many of the jobs in the laboratory, repair facility, or on the production line do not absolutely require good listening or speaking ability, but the need for good vision is a must. Color vision, depth perception, and/or a good good field of vision is also essential for some jobs.

CAREER IMPLICATIONS

Trainees and apprentices may advance from electronics worker to electronics/electromechanical technician, and may specialize in development, instrumentation, industrial controls, computers, laboratory services, production, robotics, broadcast and communications, maintenance, general electronics, or specialized military applications; some may branch into sales. With additional training and experience, some may become supervisors. Others, with additional college education may advance to professional engineers or scientists.

Some technicians with requisite education and experience may obtain certification from the Society of Manufacturing Engineers or from the Institute for the Certification of Engineering Technicians. However, such certification is rarely a condition of employment. Others may be certified by the Federal Aviation Agency in order to work with that agency.

Aspiring technicians may enter the field by applying directly to employers, but those candidates without some credentials are unlikely to be hired above the helper level. Candidates may explore the field with part-time or summer employment, or by service with reserve or active military organizations. Others may quality for and complete apprenticeships.

Employment of electrical and electronics technicians is expected to increase much faster than the average for all occupations through the mid-1990's due to increased demand for computers, communications equipment, military electronics, and electronic consumer goods. More technicians will be needed to help develop, produce, and service these products. Opportunities will be best for graduates of postsecondary school technical training programs such as the Electronics/Electromechanical Master Technician Program.

The occupational attachment, growth, and annual turnover of this occupation make it one of the most, if not the most, attractive field for young people to enter this decade.

COMPENSATION

The following represents the average entry-level salary for the largest job areas under the electronics/electromechanical technology. Jobs in electromechanical technology are slotted under the general title of electronics technicians.

	Hour	Week	Month	Year
Electronics Technician	$ 9.40	$376	$1,504	$18,048
Office Machine Servicer	7.60	304	1,216	14,592
TV and Radio Repairer	6.75	270	1,080	12,960
Telephone Maintenance Mechanic	8.30	332	1,328	15,936

EDUCATION AND TRAINING

Few workers can obtain employment in electronics/electromechanical technology or electronics servicing without having acquired some specialized technical training. If, however, the demand for these technicians exceeds the supply, some may qualify for apprenticeship or on-the-job training programs.

Education and training in preparation for employment in this occupation may be acquired as follows:

1. Universities and Colleges. Undergraduates who have not completed their degree work in electronics/electromechanical engineering are excellent candidates for technical occupations as are graduates with degrees in science or mathematics who have some specialized electronics/electromechanical technology exposure.

2. Thomas Nelson Community College. Courses taken at TNCC would include: orientation, health/PE, engineering technical math, college physics, communication skills, technical writing, economics, government, psychology, advanced electronics, graphics, materials and processes of industry, control circuits, robotics, instruments and measurements, intro to microprocessors, fluid mechanics, intro to electrical machines, instrumentation and controls, intro to computers, industrial electrical power, digital logic circuits, communications/circuits, dynamics, statics, strength of materials, microwaves, lasers, and fiber optics.

3. Armed Forces. The armed forces train many types of electronics technicians. Since they are training recruits for specific jobs, most military training programs are long on technical training and short on theory. Veterans generally qualify for non-military electronics/electromechanical technician jobs with minimal supplemental training.

4. Technical Institutes, Proprietary Schools, or Private Career Schools. Commonwealth College and Virginia Institute of Technology offer 10- to 24- month courses in electronics technology to include basic theory, circuits, inductance, resistance, capacitance, semiconductors, oscillators, amplifiers, digital electronics, logic elements, microprocessor, programming, memory modes, and hardware.

5. New Horizons Technical Center. High school students from Hampton, Newport News, Poquoson, Williamsburg/James City County, and York County may take their secondary electronics training through New Horizons Technical Center. The requirements of the vocational-technical center course match the requirements of those programs offered through the comprehensive high school.

6. High Schools. Courses taken in the electronics/electromechanical program at the high school level would include: English, health/PE, U.S./Virginia history, U.S./Virginia government, world studies/ geography, algebra I and II, geometry, earth science, principles of technology, physics, chemistry, electronics, materials and processes of industry, mechanical drawing, and power and transportation.

7. Apprenticeship Programs. Electronics/electromechanical technology is an apprenticeable occupation in Virginia, usually built around a 2- to 4- year program. The National Aeronautics and Space Administration conducts an apprenticeship program at Langley Research Center, and Newport News Shipbuilding and Dry Dock Company.

8. On-The-Job-Training. It is possible to acquire electronics/elec-electromechanical technology training on the job. However, rising above lower level positions, without some additional training, is virtually impossible.

Generally speaking, all institutions offering the technical training associated with electronics/electromechanical technology will provide an opportunity for employment.

SECTION II
TASK/COMPETENCY ANALYSIS

One of the major characteristics of competency based education (CBE) is that the course content is based on actual jobs or tasks performed by persons working in the technological world. In Virginia, the Department of Education has established standards for competency based education, as were outlined in our introduction.

These "role-relevant" jobs or tasks, called competencies in CBE must be identified and validated before instructional materials are developed and subsequent instruction takes place.

The task list contained in this instructional guide was based on the following:

1. Data collected for research was obtained through an ERIC search, materials received from VTECS and MAVCC (Mid-America Vocational Curriculum Consortium), and information from East Central Florida consortium and DACUM.

2. A DACUM workshop held for first-line supervisors and middle managers from the following local business, industry, and governmental agencies:

    - Bendix Electronics of Allied Automotive
    - Modern Machine and Tool
    - NASA
    - Newport News Shipbuilding and Dry Dock Co.
    - Philip Morris-York Engineering
    - PRC Kentron International, Inc.
    - Pressure Systems, Inc.
    - Teledyne Hastings-Raydist
    - Virginia Power
    - Wyle Laboratories

3. Input from local vocational, science, and mathematics teachers, supervisors, chairmen, and administrators from the secondary and postsecondary levels of education, and curriculum specialists from both the state and local levels. Personnel involved came from:

    - Thomas Nelson Community College
    - New Horizons Technical Center
    - The school districts of:
        - Hampton
        - Newport News
        - Poquoson
        - Williamsburg/James City County
        - York County

Based upon the information collected and reviewed from the available sources indicated, a task inventory was prepared.

The next major step involved in the development of the task inventory was validation of the task list. Validation is essential if the information collected is to be useful in operating CBE courses and programs. The validation process involved the following:

1. Review by the writing team members to determine completeness of the inventory.
2. Review and validation by representatives from local business, industry, and government agencies to insure role-relevancy and completeness of the inventory.
3. Review by local vocational, science, and mathematics teachers, supervisors, chairmen, administrators, and a curriculum specialist from the secondary and postsecondary levels of education.
4. Final review and editing by the writing team members, project directors, and curriculum specialist.

The task list included in this instructional guide is based on current available resources and validated by teachers, advisory committee members, and persons employed in vocational and technology education. Tasks included in this inventory were developed to be universal, therefore, all tasks are applicable for any given locality. It is essential that all instruction be based on the validated task analysis included in this instructional guide.

The task list has been arranged in a suggested teaching sequence. This sequence is an interdisciplinary approach. Close examination of the sequence will reveal the need to develop skills in a manner that is continuous and relevant to the subject matter following in the sequence.

The task analysis sheets are arranged by duty areas. Information contained on each form is as follows:

- The task/competency for a given duty area which is essential to persons who are preparing for advanced training.
- Program and course application information.
- Performance and enabling objectives for instructional materials developed.
- Criterion-refereced measures or test items used to determine successful attainment of the task/competency.
- Learning activities and steps for teaching the task/competency.
- Tools, materials, and supplies recommended as instructional aids.
- References and audiovisual materials helpful in teaching the task/competency.

DUTY AREA

DEMONSTRATING D.C. KNOWLEDGE

TASK/COMPETENCY SEQUENCE

1.1 Identify the parts of the atom

1.2 Identify conductors, insulators, and semiconductors

1.3 Identify resistors

1.4 Use Ohm's law formula

1.5 Measure resistance, current, and voltage drop in a D.C. resistive circuit

1.6 Analyze the relationship between R and I in a resistor

1.7 Identify series circuit characteristics

1.8 Identify parallel circuit characteristics

1.9 Identify series-parallel circuit characteristics

1.10 Analyze loaded and unloaded resistive voltage divider circuits

1.11 Analyze D.C. circuits using Kirchhoff's law

1.12 Analyze D.C. circuits using the superposition theorem

1.13 Use Thevenin's and Norton's theorems

1.14 Use Millman's theorem

1.15 Analyze bridge circuits

1.16 Identify types of batteries

1.17 Demonstrate the laws of magnetism

1.18 Explain magnetic hysteresis

1.19 Determine the magnetic polarity of a solenoid

DUTY AREA

PROGRAM

1. DEMONSTRATING D.C. KNOWLEDGE

TASK/COMPETENCY

COURSE

1.1 Identify the parts of the atom

1.1

PERFORMANCE OBJECTIVE

P 1.1 Given the periodic table of the elements and drawings for three (3) common elements, identify the parts of the atom by labeling each part and its polarities without error.

SELECTED ENABLING OBJECTIVES

E 1.1.1 Identify elements in the periodic table.

E 1.1.2 Determine the number of electrons, protons, and neutrons in an atom.

E 1.1.3 Draw a diagram of an atom and label its parts.

E 1.1.4 Identify the negative and positive charges in an atom.

CRITERION-REFERENCED MEASURE

C 1.1 Identify the parts of an atom by labeling each part and its polarities without error.

The Atom and Its Particles

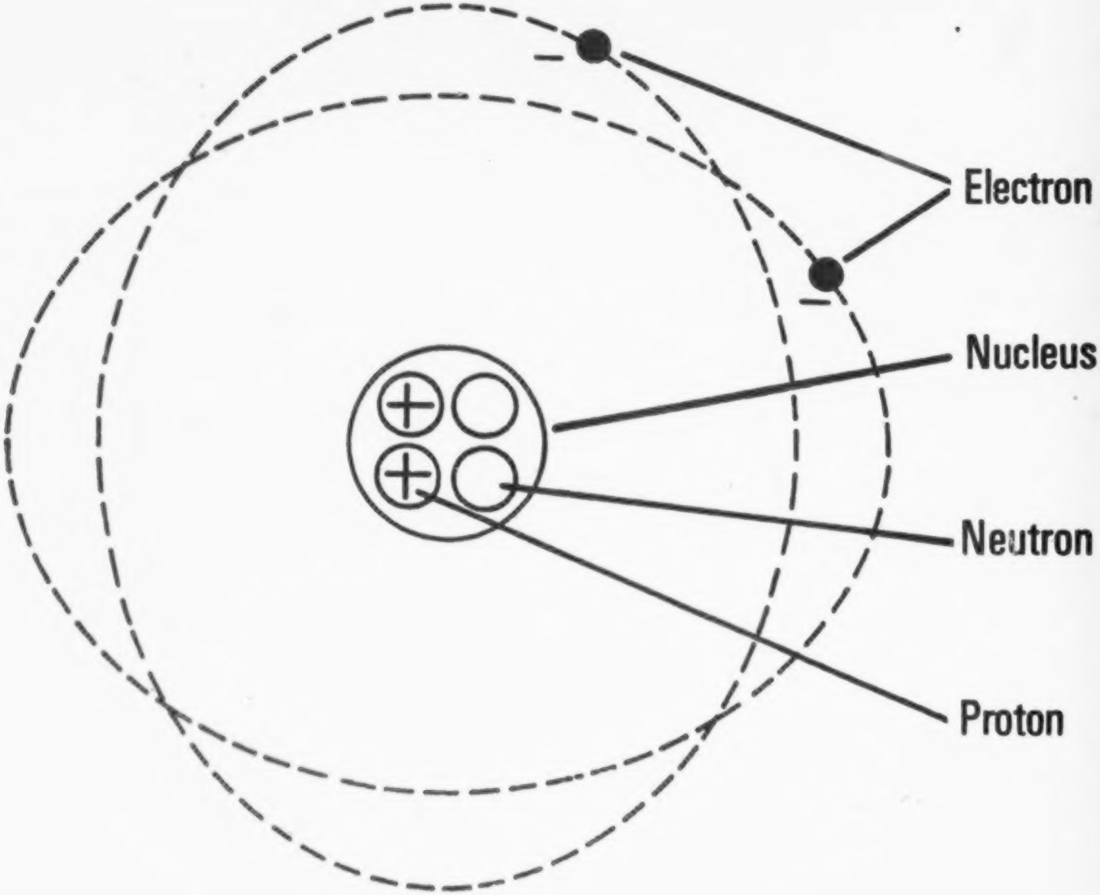

Electron
Nucleus
Neutron
Proton

TABLE OF PERIODIC PROPERTIES OF THE ELEMENTS

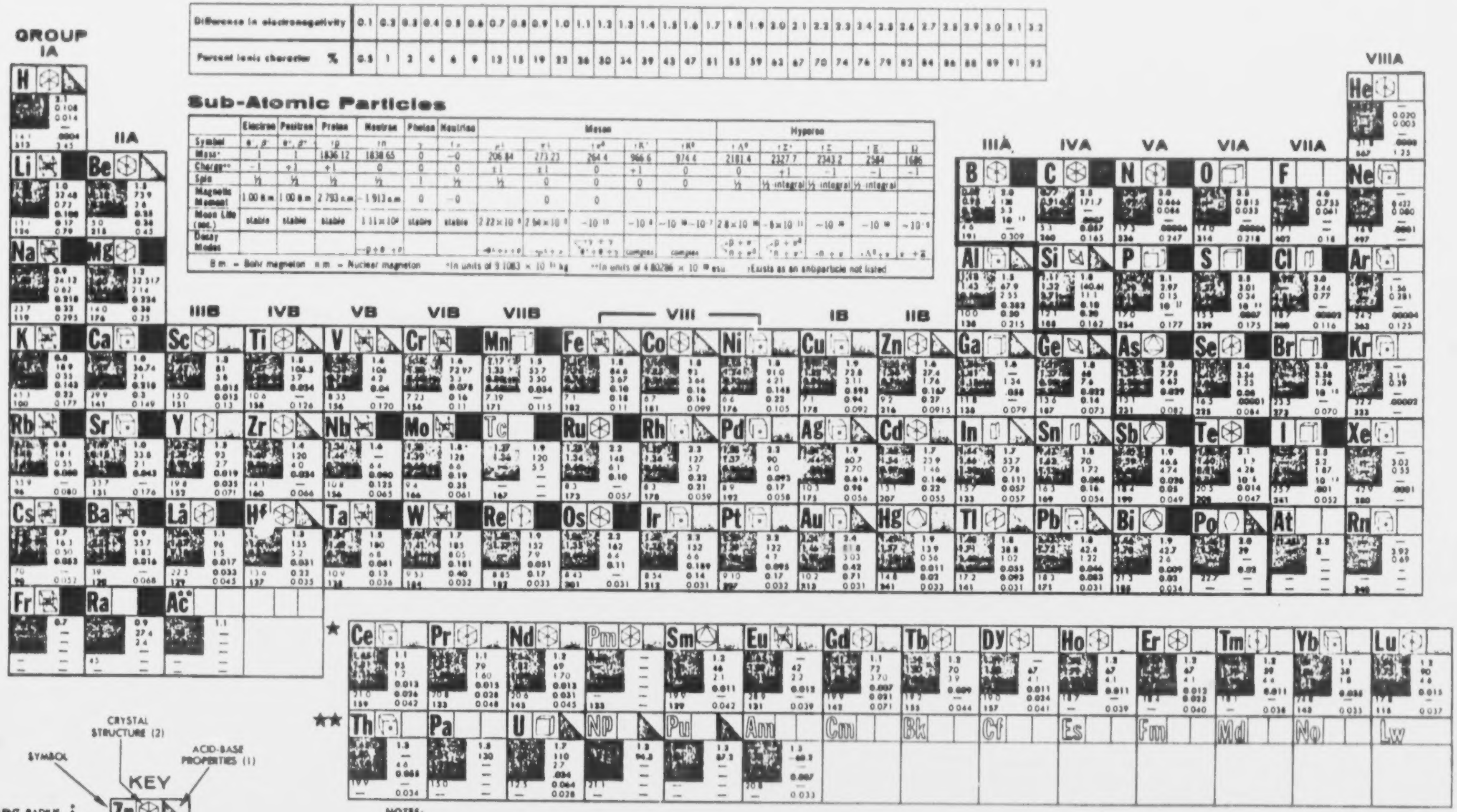
Percent Ionic Character of a Single Chemical Bond

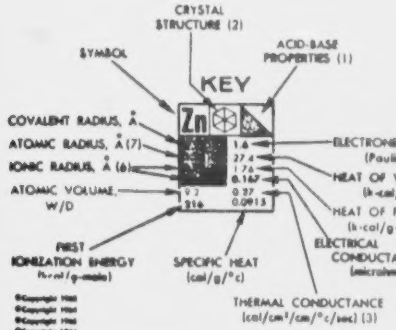
Difference in electronegativity	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9	2.0	2.1	2.2	2.3	2.4	2.5	2.6	2.7	2.8	2.9	3.0	3.1	3.2
Percent ionic character %	0.5	1	2	4	6	9	12	15	19	22	26	30	34	39	43	47	51	55	59	63	67	70	74	76	79	82	84	86	88	89	91	92

Sub-Atomic Particles

	Electron	Positron	Proton	Neutron	Photon	Neutrino	Meson					Hyperon				
Symbol	e^-, β^-	e^+, β^+	^1_1p	^1_0n	γ	$\dagger\nu$	$\mu^\pm$	$\pi^\pm$	$\dagger\pi^0$	$\dagger K^+$	$\dagger K^0$	$\dagger\Lambda^0$	$\dagger\Sigma^+$	$\dagger\Sigma^-$	$\dagger\Xi^-$	Ω^-
Mass*	1	1	1836.12	1838.65	0	~0	206.84	273.23	264.4	966.6	974.4	2181.4	2327.7	2343.2	2584	1686
Charge**	−1	+1	+1	0	0	0	±1	±1	0	+1	0	0	+1	−1	−1	−1
Spin	½	½	½	½	1	½	½	0	0	0	0	½	½ integral	½ integral	½ integral	
Magnetic Moment	1.00 B.m.	1.00 B.m.	2.793 n.m.	−1.913 n.m.	0	~0		0	0							
Mean Life (sec.)	stable	stable	stable	1.11×10^3	stable	stable	2.22×10^{-6}	2.56×10^{-8}	$\sim 10^{-16}$	$\sim 10^{-8}$	$\sim 10^{-10}$–10^{-7}	2.8×10^{-10}	$\sim 8 \times 10^{-11}$	$\sim 10^{-10}$	$\sim 10^{-10}$	$\sim 10^{-10}$
Decay Modes				$\rightarrow p + \beta^- + \bar{\nu}$			$\rightarrow \beta^\pm + \nu + \bar{\nu}$	$\rightarrow \mu^\pm + \nu$	$\rightarrow \gamma + \gamma$ $\beta^+ + \beta^- + \gamma$	complex	complex	$\rightarrow p + \pi^-$ $n + \pi^0$	$\rightarrow p + \pi^0$ $n + \pi^+$	$\rightarrow n + \pi^-$	$\rightarrow \Lambda^0 + \pi^-$	$\pi^- + \Xi$

B.m. = Bohr magneton n.m. = Nuclear magneton *In units of 9.1083×10^{-31} kg **In units of 4.80286×10^{-10} esu †Exists as an antiparticle not listed


GROUP IA
IIA
IIIB
IVB
VB
VIB
VIIB
VIII
IB
IIB
IIIA
IVA
VA
VIA
VIIA
VIIIA
H
He
Li
Be
B
C
N
O
F
Ne
Na
Mg
Al
Si
P
S
Cl
Ar
K
Ca
Sc
Ti
V
Cr
Mn
Fe
Co
Ni
Cu
Zn
Ga
Ge
As
Se
Br
Kr
Rb
Sr
Y
Zr
Nb
Mo
Tc
Ru
Rh
Pd
Ag
Cd
In
Sn
Sb
Te
I
Xe
Cs
Ba
La*
Hf
Ta
W
Re
Os
Ir
Pt
Au
Hg
Tl
Pb
Bi
Po
At
Rn
Fr
Ra
Ac**
★
Ce
Pr
Nd
Pm
Sm
Eu
Gd
Tb
Dy
Ho
Er
Tm
Yb
Lu
★★
Th
Pa
U
Np
Pu
Am
Cm
Bk
Cf
Es
Fm
Md
No
Lw


CRYSTAL STRUCTURE (2)
SYMBOL
ACID-BASE PROPERTIES (1)
KEY
Zn
COVALENT RADIUS, Å
ATOMIC RADIUS, Å (7)
IONIC RADIUS, Å (6)
ATOMIC VOLUME, W/D
FIRST IONIZATION ENERGY (k-cal/g-mole)
SPECIFIC HEAT (cal/g/°c)
THERMAL CONDUCTANCE (cal/cm²/cm/°c/sec) (3)
ELECTRICAL CONDUCTANCE (5) (microhms)⁻¹
HEAT OF FUSION (k-cal/g-atom)
HEAT OF VAPORIZATION (k-cal/g-atom) (4)
ELECTRONEGATIVITY (Pauling's)
1.6
27.4
1.76
0.167
9.2
0.27
216
0.0913

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NOTES:

(1) For representative oxides (higher valence) of group. Oxide is acidic if color is red, basic if color is blue and amphoteric if both colors are shown. Intensity of color indicates relative strength.

(2) Cubic, face centered; cubic, body centered; diamond; cubic; hexagonal; rhombohedral; tetragonal; orthorhombic; monoclinic.

(3) At room temperature. (4) At boiling point. (5) From 0° to 20°C.

(6) Ionic (crystal) radii for coordination number 6.

(7) Metallic radii for coordination number of 12.

Catalog Number S-18806 SIDE 2

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PERIODIC TABLE OF THE ELEMENTS

Table of Radioactive Isotopes

Ac 227(22y)β^-,α
Ag 110(24s)β^-,γ
111(7.5d)β^-,γ
Am 241(458y)α,γ,e^-
242(16.0h)β^-,K,α,γ
243(8000y)α,γ
As 76(26.7h)β^-,γ
77(39h)β^-,γ
At 210(8.3h)K,α,γ
211(7.2h)K,α,γ
Au 198(2.69d)β^-,γ
Ba 131(12d)K,γ
133(7.2y)K,γ,e^-
Bi 210(5d)β^-,α
Bk 243(4.9d)K,α,γ
249(314d)β^-,α,SF
Br 82(36h)β^-,γ
C 14(5700y)β^-
Ca 41(8×10^{4}y)K
45(165d)β^-
47(4.5d)β^-,γ

Cd 115(43d)β^-,γ
Ce 141(32d)β^-,γ
143(33h)β^-,γ
144(285d)β^-,γ
Cf 246(35h)α,γ,SF
249(360y)α,γ,SF
251(800y)γ
Cl 36(3×10^{5}y)β^-
Cm 243(35y)α,γ
245(9300y)α,γ
247(10^{7}y)
Co 58(71d)K,β^+,γ
60(5.27y)β^-,γ
Cr 51(27d)K,γ
Cs 134(2.0y)β^-,γ
135(3×10^{6}y)β^-
137(30y)β^-,γ
Cu 64(12.8h)K,β^-,β^+,γ
Es 253(20d)α,γ,SF
254(1y)α,SF
Eu 154(16y)β^-,γ
155(1.8y)β^-,γ

Fe 55(2.6y)K
59(45d)β^-,γ
Fm 255(20h)α
Fr 223(22m)β^-,γ,α
Ga 72(14.1h)β^-,γ
Gd 153(236d)K,γ,e^-
159(18h)β^-,γ
Ge 71(11d)K
H 3(12.3y)β^-
Hf 181(45d)β^-,γ,e^-
Hg 197(65h)K,γ,e^-
203(47d)β^-,γ,e^-
Ho 166(27.3h)β^-,γ
I 129(10^{7}y)β^-,γ,e^-
131(8.05d)β^-,γ
In 114(50d)γ
Ir 192(74.4d)β^-,γ
K 40(10^{9}y)β^-,K,γ
42(12.4h),β^-,γ

La 140(40.2h)β^-,γ
Lu 176(10^{10}y)β^-,K,γ
177(6.8d)β^-,γ
Md 256(90m)K,SF
Mo 99(67h)β^-,γ
Na 22(2.6y)β^+,K,γ
24(15h)β^-,γ
Nd 147(11.1d)β^-,γ
Ni 63(125y)β^-
59(8×10^{4}y),K
Np 237(2.2×10^{6}y)α,γ
239(2.33d)β^-,γ
Os 191(15d)β^-,γ,e^-
P 32(14.2d)β^-
Pa 231(34000y)α,γ
Pb 210(19.4y)β^-,γ,e^-
202(10^{5}y)K
Pd 103(17d)K,γ
Pm 147(2.6y)β^-

Po 210(138.4d)α,γ
209(103y)α,K,γ
Pr 143(13.8d)β^-
Pt 197(18h)β^-,γ
Pu 242(3.8 × 10^{5}y)α,SF
241(13y)β^-,α,γ
239(24300y)α,γ,SF
Ra 226(1620y)α,γ
Rb 86(18.6d)β^-,γ
Re 188(16.7h)β^-,γ
186(3.7d)β^-,γ
Rn 222(3.82d)α
Ru 103(40d)β^-,γ
97(2.9d),K,γ,e^-
S 35(88d)β^-
Sb 122(2.8d)β^-,K,β^+,γ
124(60d)β^-,γ
Sc 46(84d)β^-,γ
Se 75(120d)K,γ
Sm 153(47h)β^-,γ
145(340d)K,γ
Sn 113(119d)K,L,γ,e^-

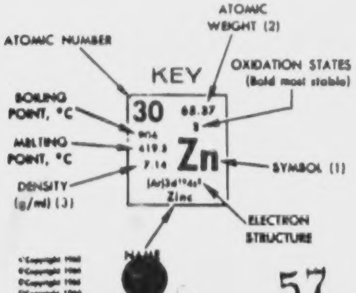
Sr 90(28y)β^-
89(51d)β^-,γ
85(64d)K,γ
Ta 182(115d)β^-,γ
Tb 160(73d)β^-,γ
Tc 99(2×10^{5}y)β^-
97(10^{6}y)K
Te 127(9.3h)β^-
Th 232(1.4×10^{10}y)α,γ,SF
228(1.91y)β^-
Tl 204(3.81y)β^-,K
Tm 170(134d)β^-,γ,e^-
U 238(4.5×10^{9}y)α,γ,SF
234(2.5×10^{5}y)α,γ,SF
235(7.1×10^{8}y)α,γ,SF
233(1.6×10^{5}y)α,γ
W 185(75d)β^-
Y 90(64h)β^-,e^-
Yb 175(4.2d)β^-,γ
169(31d)K,γ,e^-
Zn 65(245d)K,β^+,γ
Zr 95(65d)β^-,γ,e^-
93(9×10^{5}y)β^-,γ

Naturally occurring radioactive isotopes are indicated by a blue mass number. Half lives are in parentheses where s, m, h, d and y stand for seconds, minutes, hours, days and years respectively. The symbols describing the mode of decay and resulting radiation are defined as follows:

α	alpha particle	L	L-electron capture
β^-	beta particle	SF	spontaneous fission
β^+	positron	γ	gamma ray
K	K-electron capture	e^-	internal electron conversion

GROUP IA	IIA	IIIB	IVB	VB	VIB	VIIB	VIII	VIII	VIII	IB	IIB	IIIA	IVA	VA	VIA	VIIA	VIIIA
1 1.00797 1 -252.7 -259.2 0.071 H $1s^1$ Hydrogen																	2 4.0026 -268.9 -269.7 0.126 He $1s^2$ Helium
3 6.939 1 1330 180.5 0.53 Li $1s^2\ 2s^1$ Lithium	4 9.0122 2 2770 1277 1.85 Be $1s^2\ 2s^2$ Beryllium											5 10.811 3 — (2030) 2.34 B $1s^2\ 2s^2\ 2p^1$ Boron	6 12.01115 ±4,2 4830 3727 2.26 C $1s^2\ 2s^2\ 2p^2$ Carbon	7 14.0067 ±3,5,4,2 -195.8 -210 0.81 N $1s^2\ 2s^2\ 2p^3$ Nitrogen	8 15.9994 -2 -183 -218.8 1.14 O $1s^2\ 2s^2\ 2p^4$ Oxygen	9 18.9984 -1 -188.2 -219.6 1.305 F $1s^2\ 2s^2\ 2p^5$ Fluorine	10 20.183 -246 -248.6 1.20 Ne $1s^2\ 2s^2\ 2p^6$ Neon
11 22.9898 1 892 97.8 0.97 Na $[Ne]3s^1$ Sodium	12 24.312 2 1107 650 1.74 Mg $[Ne]3s^2$ Magnesium											13 26.9815 3 2450 660 2.70 Al $[Ne]3s^2 3p^1$ Aluminum	14 28.086 4 2680 1410 2.33 Si $[Ne]3s^2 3p^2$ Silicon	15 30.9738 ±3,5,4 280w 44.2w 1.82w P $[Ne]3s^2 3p^3$ Phosphorus	16 32.064 ±2,4,6 444.6 119.0 2.07 S $[Ne]3s^2 3p^4$ Sulfur	17 35.453 ±1,3,5,7 -34.7 -101.0 1.56 Cl $[Ne]3s^2 3p^5$ Chlorine	18 39.948 -185.8 -189.4 1.40 Ar $[Ne]3s^2 3p^6$ Argon
19 39.102 1 760 63.7 0.86 K $[Ar]4s^1$ Potassium	20 40.08 2 1440 838 1.55 Ca $[Ar]4s^2$ Calcium	21 44.956 3 2730 1539 3.0 Sc $[Ar]3d^1 4s^2$ Scandium	22 47.90 4,3 3260 1668 4.51 Ti $[Ar]3d^2 4s^2$ Titanium	23 50.942 5,4,3,2 3450 1900 6.1 V $[Ar]3d^3 4s^2$ Vanadium	24 51.996 6,3,2 2665 1875 7.19 Cr $[Ar]3d^5 4s^1$ Chromium	25 54.938 7,6,4,2,3 2150 1245 7.43 Mn $[Ar]3d^5 4s^2$ Manganese	26 55.847 2,3 3000 1536 7.86 Fe $[Ar]3d^6 4s^2$ Iron	27 58.933 2,3 2900 1495 8.9 Co $[Ar]3d^7 4s^2$ Cobalt	28 58.71 2,3 2730 1453 8.9 Ni $[Ar]3d^8 4s^2$ Nickel	29 63.54 2,1 2595 1083 8.96 Cu $[Ar]3d^{10} 4s^1$ Copper	30 65.37 2 906 419.5 7.14 Zn $[Ar]3d^{10} 4s^2$ Zinc	31 69.72 3 2237 29.8 5.91 Ga $[Ar]3d^{10} 4s^2 4p^1$ Gallium	32 72.59 4 2830 937.4 5.32 Ge $[Ar]3d^{10} 4s^2 4p^2$ Germanium	33 74.922 ±3,5 613° 817 5.72 As $[Ar]3d^{10} 4s^2 4p^3$ Arsenic	34 78.96 -2,4,6 685 217 4.79 Se $[Ar]3d^{10} 4s^2 4p^4$ Selenium	35 79.909 ±1,5 58 -7.2 3.12 Br $[Ar]3d^{10} 4s^2 4p^5$ Bromine	36 83.80 -152 -157.3 2.6 Kr $[Ar]3d^{10} 4s^2 4p^6$ Krypton
37 85.47 1 688 38.9 1.53 Rb $[Kr]5s^1$ Rubidium	38 87.62 2 1380 768 2.6 Sr $[Kr]5s^2$ Strontium	39 88.905 3 2927 1509 4.47 Y $[Kr]4d^1 5s^2$ Yttrium	40 91.22 4 3580 1852 6.49 Zr $[Kr]4d^2 5s^2$ Zirconium	41 92.906 5,3 3300 2468 8.4 Nb $[Kr]4d^4 5s^1$ Niobium	42 95.94 6,5,4,3,2 5560 2610 10.2 Mo $[Kr]4d^5 5s^1$ Molybdenum	43 (98) 7 — 2140 11.5 Tc $[Kr]4d^5 5s^2$ Technetium	44 101.07 2,3,4,6,8 4900 2500 12.2 Ru $[Kr]4d^7 5s^1$ Ruthenium	45 102.905 2,3,4 4500 1966 12.4 Rh $[Kr]4d^8 5s^1$ Rhodium	46 106.4 2,4 3980 1552 12.0 Pd $[Kr]4d^{10} 5s^0$ Palladium	47 107.870 1 2210 960.8 10.5 Ag $[Kr]4d^{10} 5s^1$ Silver	48 112.40 2 765 320.9 8.65 Cd $[Kr]4d^{10} 5s^2$ Cadmium	49 114.82 3 2000 156.2 7.31 In $[Kr]4d^{10} 5s^2 5p^1$ Indium	50 118.69 4,2 2270 231.9 7.30 Sn $[Kr]4d^{10} 5s^2 5p^2$ Tin	51 121.75 ±3,5 1380 630.5 6.62 Sb $[Kr]4d^{10} 5s^2 5p^3$ Antimony	52 127.60 -2,4,6 989.8 449.5 6.24 Te $[Kr]4d^{10} 5s^2 5p^4$ Tellurium	53 126.904 ±1,5,7 183 113.7 4.94 I $[Kr]4d^{10} 5s^2 5p^5$ Iodine	54 131.30 -108.0 -111.9 3.06 Xe $[Kr]4d^{10} 5s^2 5p^6$ Xenon
55 132.905 1 690 28.7 1.90 Cs $[Xe]6s^1$ Cesium	56 137.34 2 1640 714 3.5 Ba $[Xe]6s^2$ Barium	57 138.91 3 3470 920 6.17 La★ $[Xe]5d^1 6s^2$ Lanthanum	72 178.49 4 5400 2222 13.1 Hf $[Xe]4f^{14} 5d^2 6s^2$ Hafnium	73 180.948 5 5425 2996 16.6 Ta $[Xe]4f^{14} 5d^3 6s^2$ Tantalum	74 183.85 6,5,4,3,2 5930 3410 19.3 W $[Xe]4f^{14} 5d^4 6s^2$ Wolfram	75 186.2 7,6,4,2,-1 5900 3180 21.0 Re $[Xe]4f^{14} 5d^5 6s^2$ Rhenium	76 190.2 2,3,4,6,8 5500 3000 22.6 Os $[Xe]4f^{14} 5d^6 6s^2$ Osmium	77 192.2 2,3,4,6 5300 2454 22.5 Ir $[Xe]4f^{14} 5d^7 6s^2$ Iridium	78 195.09 2,4 4530 1769 21.4 Pt $[Xe]4f^{14} 5d^9 6s^1$ Platinum	79 196.967 3,1 2970 1063 19.3 Au $[Xe]4f^{14} 5d^{10} 6s^1$ Gold	80 200.59 2,1 357 -38.4 13.6 Hg $[Xe]4f^{14} 5d^{10} 6s^2$ Mercury	81 204.37 3,1 1457 303 11.85 Tl $[Xe]4f^{14} 5d^{10} 6s^2 6p^1$ Thallium	82 207.19 4,2 1725 327.4 11.4 Pb $[Xe]4f^{14} 5d^{10} 6s^2 6p^2$ Lead	83 208.980 3,5 1560 271.3 9.8 Bi $[Xe]4f^{14} 5d^{10} 6s^2 6p^3$ Bismuth	84 (210) 2,4 — 254 (9.2) Po $[Xe]4f^{14} 5d^{10} 6s^2 6p^4$ Polonium	85 (210) ±1,3,5,7 — (302) — At $[Xe]4f^{14} 5d^{10} 6s^2 6p^5$ Astatine	86 (222) (-61.8) (-71) — Rn $[Xe]4f^{14} 5d^{10} 6s^2 6p^6$ Radon
87 (223) 1 — (27) — Fr $[Rn]7s^1$ Francium	88 (226) 2 — 700 5.0 Ra $[Rn]7s^2$ Radium	89 (227) 3 — 1050 — Ac★★ $[Rn]6d^1 7s^2$ Actinium	104														

★	58 140.12 3,4 3468 795 6.67 Ce $[Xe]4f^2 5d^0 6s^2$ Cerium	59 140.907 3,4 3127 935 6.77 Pr $[Xe]4f^3 5d^0 6s^2$ Praseodymium	60 144.24 3 3027 1024 7.00 Nd $[Xe]4f^4 5d^0 6s^2$ Neodymium	61 (147) 3 — (1080) — Pm $[Xe]4f^5 5d^0 6s^2$ Promethium	62 150.35 3,2 1900 1072 7.54 Sm $[Xe]4f^6 5d^0 6s^2$ Samarium	63 151.96 3,2 1439 826 5.26 Eu $[Xe]4f^7 5d^0 6s^2$ Europium	64 157.25 3 3000 1312 7.89 Gd $[Xe]4f^7 5d^1 6s^2$ Gadolinium	65 158.924 3,4 2800 1356 8.27 Tb $[Xe]4f^9 5d^0 6s^2$ Terbium	66 162.50 3 2600 1407 8.54 Dy $[Xe]4f^{10} 5d^0 6s^2$ Dysprosium	67 164.930 3 2600 1461 8.80 Ho $[Xe]4f^{11} 5d^0 6s^2$ Holmium	68 167.26 3 2900 1497 9.05 Er $[Xe]4f^{12} 5d^0 6s^2$ Erbium	69 168.934 3,2 1727 1545 9.33 Tm $[Xe]4f^{13} 5d^0 6s^2$ Thulium	70 173.04 3,2 1427 824 6.98 Yb $[Xe]4f^{14} 5d^0 6s^2$ Ytterbium	71 174.97 3 3327 1652 9.84 Lu $[Xe]4f^{14} 5d^1 6s^2$ Lutetium
★★	90 232.038 4 3850 1750 11.7 Th $[Rn]5f^0 6d^2 7s^2$ Thorium	91 (231) 5,4 — (1230) 15.4 Pa $[Rn]5f^2 6d^1 7s^2$ Protactinium	92 238.03 6,5,4,3 3818 1132 19.07 U $[Rn]5f^3 6d^1 7s^2$ Uranium	93 (237) 6,5,4,3 — 637 19.5 Np $[Rn]5f^4 6d^1 7s^2$ Neptunium	94 (242) 6,5,4,3 3235 640 — Pu $[Rn]5f^6 6d^0 7s^2$ Plutonium	95 (243) 6,5,4,3 — — 11.7 Am $[Rn]5f^7 6d^0 7s^2$ Americium	96 (247) 3 — — — Cm $[Rn]5f^7 6d^1 7s^2$ Curium	97 (247) 4,3 — — — Bk $[Rn]5f^8 6d^1 7s^2$ Berkelium	98 (249) 3 — — — Cf $[Rn]5f^{10} 6d^0 7s^2$ Californium	99 (254) — — — — Es $[Rn]5f^{11} 6d^0 7s^2$ Einsteinium	100 (253) — — — — Fm $[Rn]5f^{12} 6d^0 7s^2$ Fermium	101 (256) — — — — Md $[Rn]5f^{13} 6d^0 7s^2$ Mendelevium	102 (254) — — — — No $[Rn]5f^{14} 6d^0 7s^2$ Nobelium	103 (257) — — — — Lw $[Rn]5f^{14} 6d^1 7s^2$ Lawrencium



NOTES:

(1) Black — solid.
Red — gas.
Blue — liquid.
Outline — synthetically prepared.

(2) Based upon carbon – 12. ( ) indicates most stable or best known isotope.

(3) Values for gaseous elements are for liquids at the boiling point.

SIDE 1

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SARGENT-WELCH SCIEN[illegible]IC COMPANY
7300 LINDER AVENUE, SKO[illegible]ILLINOIS 60076
CHICAGO • CINCINNATI • CLEVELAND • DETROIT • DALLAS • DENVER
BIRMINGHAM • SPRINGFIELD, N. J. • ANAHEIM, CALIF. • TORONTO, CANADA

SELECTED INSTRUCTIONAL ACTIVITIES

1. Display and discuss the periodic table. (E 1.1.1)
2. Using the periodic table, explain how to determine the number of protons, electrons, and neutrons in an atom. (E 1.1.2)
3. Demonstrate how to draw an atom and label its parts. (E 1.1.3)
4. Discuss the negative, positive, and neutral parts of an atom. (E 1.1.4)

SELECTED TOOLS AND MATERIALS

Periodic table of the elements (handout)
Overhead projector

SELECTED AUDIOVISUAL MATERIALS

"The Atom and its Particles" (transparency)
Periodic Table of the Elements (wall chart)
Direct Current #801, "The Electron Theory," Bergwall Programs

SELECTED REFERENCES

Basic Electronics, 5th Edition. Bernard Grob. (Chapter 1)

Introductory Circuit Analysis, 4th Edition. Robert L. Boylestad. (Chapter 2)

DUTY AREA

1. DEMONSTRATING D.C. KNOWLEDGE

PROGRAM

TASK/COMPETENCY

1.2 Identify conductors, insulators, and semiconductors

COURSE

1.2

PERFORMANCE OBJECTIVE

P 1.2 Given the periodic table of the elements and a list of materials, identify the three (3) most commonly used conductors, insulators, and semiconductors without error.

SELECTED ENABLING OBJECTIVES

E 1.2.1 Identify the number of electrons in each shell of an atom.

E 1.2.2 Identify the valence electrons in an atom.

E 1.2.3 Explain how the valence electrons determine if an element is a good conductor or semiconductor.

E 1.2.4 Explain what makes a material a good insulator.

E. 1.2.5 Define:

A. Insulator,
B. Conductor, and
C. Semiconductor, and explain the applications of each.

CRITERION-REFERENCED MEASURE

C 1.2 Identify the three (3) most commonly used conductors, insulators, and semiconductors without error.

SELECTED INSTRUCTIONAL ACTIVITIES

1. Explain how the atomic weight of an element determines the number of electrons and how they are distributed into shells. (E 1.2.1)

2. Explain valence electrons and how they affect the stability of an atom. (E 1.2.2 and E 1.2.3)

3. Explain why some materials are good insulators and others are good conductors. (E 1.2.4)

4. Discuss the applications of:

   A. Resistance,
   B. Conductance, and
   C. Semiconductance and their definitions. (E 1.2.5)

SELECTED TOOLS AND MATERIALS

SELECTED AUDIOVISUAL MATERIALS

Periodic Table of the Elements (wall chart)

SELECTED REFERENCES

Basic Electronics, 5th Edition. Bernard Grob. (Chapter 1)

Introductory Circuit Analysis, 4th Edition. Robert L. Boylestad. (Chapter 2)

DUTY AREA

1. DEMONSTRATING D.C. KNOWLEDGE

PROGRAM

TASK/COMPETENCY

1.3 Identify resistors

COURSE

1.3

PERFORMANCE OBJECTIVE

P 1.3 Given several different types of resistors, identify each in terms of its type, value, and schematic symbol without error.

SELECTED ENABLING OBJECTIVES

E 1.3.1 Define:

A. Resistor,
B. Fixed resistor
C. Variable resistor,
D. Nonlinear resistor,
E. Rheostate, and
F. Potentiometer.

E 1.3.2 Calculate the resistance of 2000 feet of number 18 copper wire.

E 1.3.3 Define:

A. Kilo,
B. Mega,
C. Failure rate,
D. Multiplier,
E. Significant figure, and
F. Tolerance.

E 1.3.4 Explain how to determine the wattage rating of a fixed carbon composition resistor.

E 1.3.5 Demonstrate how to read and interpret the resistor color code.

E 1.3.6 Draw the schematic symbol for:

A. Fixed R,
B. Variable R,
C. Potentiometer, and
D. Rheostate, and given an application for each.

CRITERION-REFERENCED MEASURE

C 1.3 Identify each resistor in terms of its type, value, and schematic symbol without error.

SELECTED INSTRUCTIONAL ACTIVITIES

1. Discuss resistance in terms of:

    A. The different types of resistors,
    B. The temperature effect on resistors,
    C. The resistivity of various materials,
    D. Wire size American Wire Gauge (AWG),
    E. Schematic symbols, and
    F. Wattage rating. (E 1.3.1, E 1.3.2, E 1.3.4, and E 1.3.6)

2. Explain the different types of resistors used in electronic circuits. (E 1.3.6)

3. Give several examples of both fixed and variable (linear and nonlinear tapers), and explain their applications. (E 1.3.6)

4. Explain the resistor color code and how it is used. (E 1.3.3 and E 1.3.5)

5. Explain the difference between a rheostat and a potentiometer in circuit applications. (E 1.3.6)

SELECTED TOOLS AND MATERIALS

Assorted color-coded resistors including ¼W, ½W, 1W, 2W composition
Color-coded wire-wound resistors (EIA and MIL standard)
Adjustable resistors, rheostats, and potentiometers

SELECTED AUDIOVISUAL MATERIALS

Electronic Industrial Association (EIA) color-coded chart

SELECTED REFERENCES

Basic Electronics, 5th Edition. Bernard Grob. (Chapters 1 and 6)

Introductory Circuit Analysis, 4th Edition. Robert L. Boylestad. (Chapter 3)

DUTY AREA

PROGRAM

1. DEMONSTRATING D.C. KNOWLEDGE

TASK/COMPETENCY

COURSE

1.4 Use Ohm's law formula

1.4

PERFORMANCE OBJECTIVE

P 1.4 Given Ohm's law and two (2) of the three (3) variables for five (5) different sample circuits, use Ohm's law to solve for the third variable in each circuit and the power dissipated in the resistance; all calculated values must be within 1% of instructor-calculated values.

SELECTED ENABLING OBJECTIVES

E 1.4.1 Define coulomb.

E 1.4.2 Define current and state its unit of measure.

E 1.4.3 Define voltage and state its unit of measure.

E 1.4.4 State three (3) common methods of producing electricity.

E 1.4.5 Explain the difference between conventional current and electron flow.

E 1.4.6 Solve Ohm's law for any variable in terms of the other two (2) variables.

E 1.4.7 Given several simple circuits which include any two (2) of the values of voltage, current, or resistance, select the appropriate form of Ohm's law and calculate the third variable.

E 1.4.8 Explain the difference between energy and power and state the unit of measure for each.

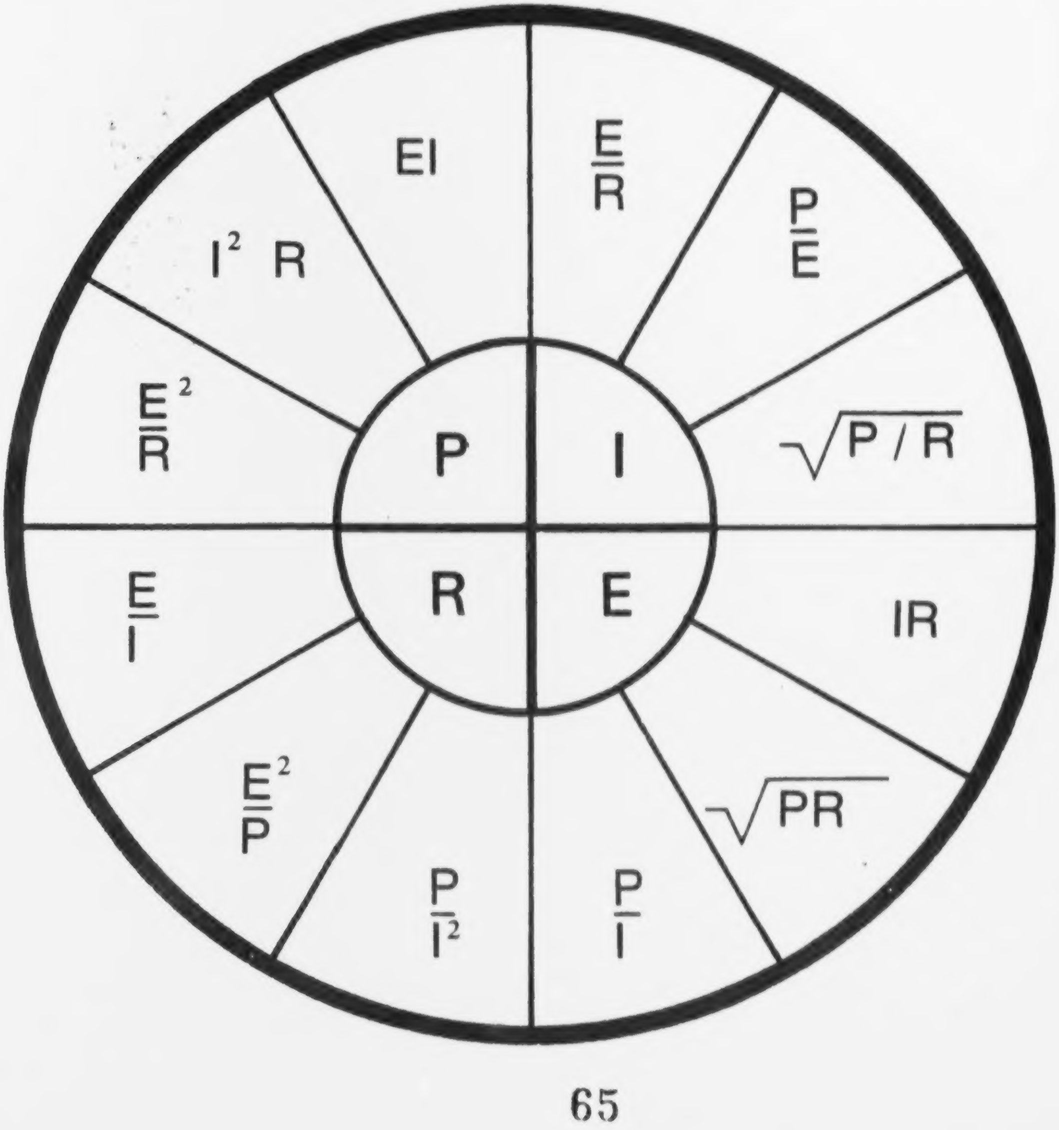
E 1.4.9 Calculate power dissipated in the resistance of each circuit given in E 1.4.7.

E 1.4.10 State two (2) safety precautions to follow when working on electrical circuits.

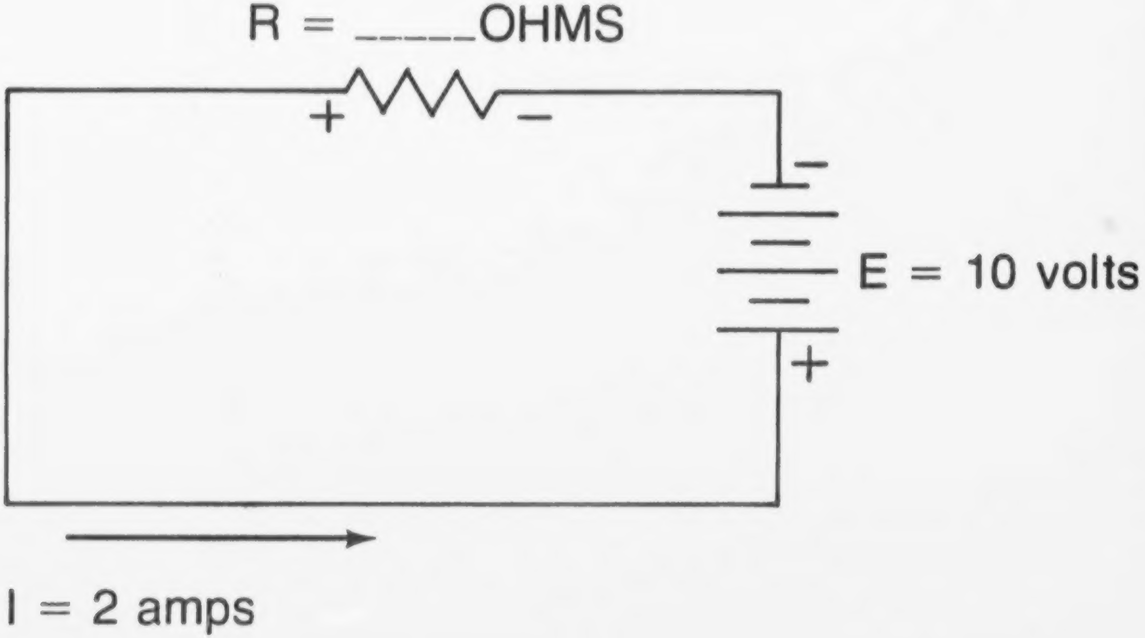
CRITERION-REFERENCED MEASURE

C 1.1 Use Ohm's law to solve for the third variable in each circuit and the power dissipated in the resistance; all calculated values must be within 1% of instructor calculated values.

Memory Wheel for Solving Problems


P
I
R
E
EI
$I^2 R$
$\frac{E^2}{R}$
$\frac{E}{R}$
$\frac{P}{E}$
$\sqrt{P/R}$
IR
$\sqrt{PR}$
$\frac{P}{I}$
$\frac{P}{I^2}$
$\frac{E^2}{P}$
$\frac{E}{I}$

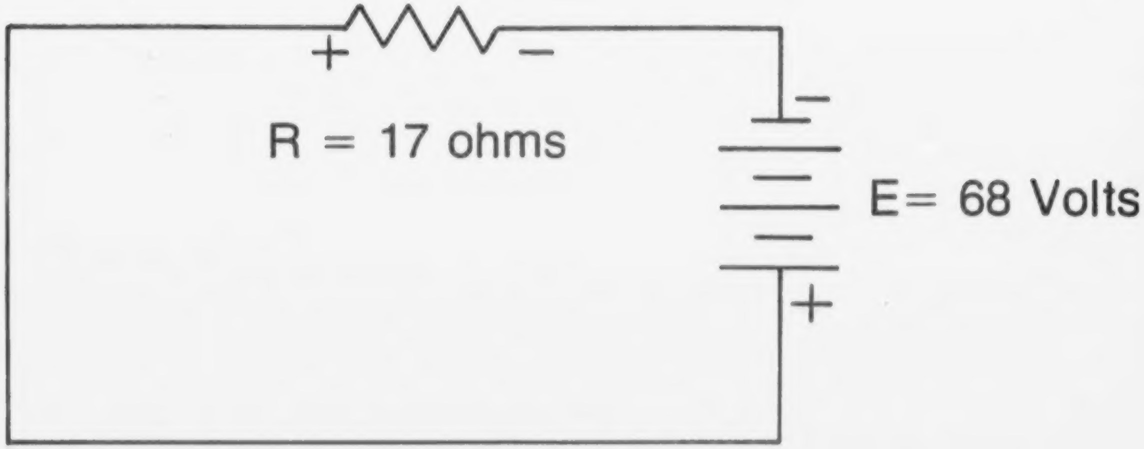
Ohm's Law--Computing Resistance


R = _____OHMS
+
−
−
E = 10 volts
+
I = 2 amps

What is the resistance value of the resistor in this circuit?

$$E = IR \qquad R = \frac{E}{I} \qquad R = \frac{10 \text{ volts}}{2 \text{ amperes}} = 5 \text{ ohms}$$

Ohm's Law--Computing Current

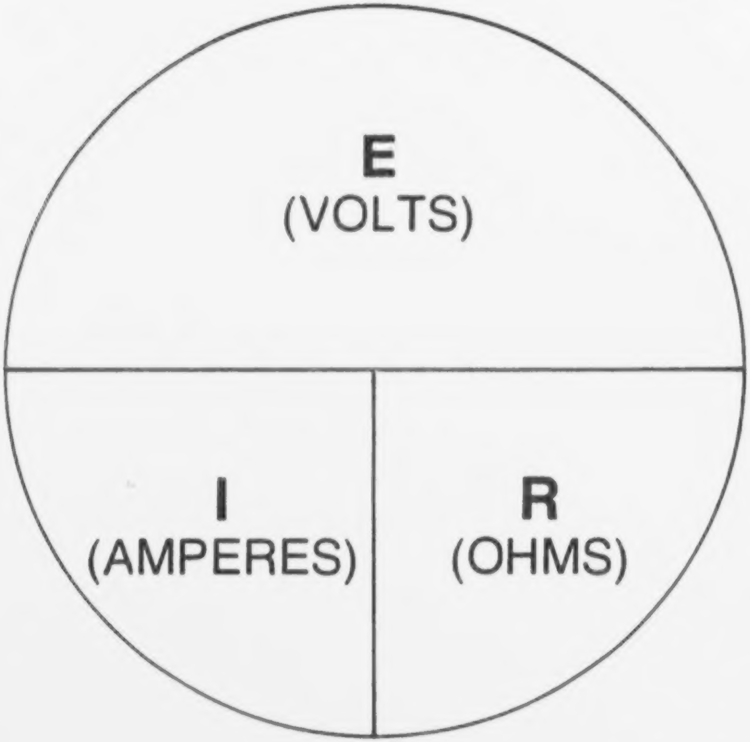

+
−
R = 17 ohms
−
E= 68 Volts
+

I = _____ amps

How many amperes of current are flowing in this circuit?

$E = IR$ $\quad I = \frac{E}{R}$ $\quad I = \frac{68 \text{ volts}}{17 \text{ ohms}} = 4 \text{ amperes}$

Ohm's Law Magic Circle

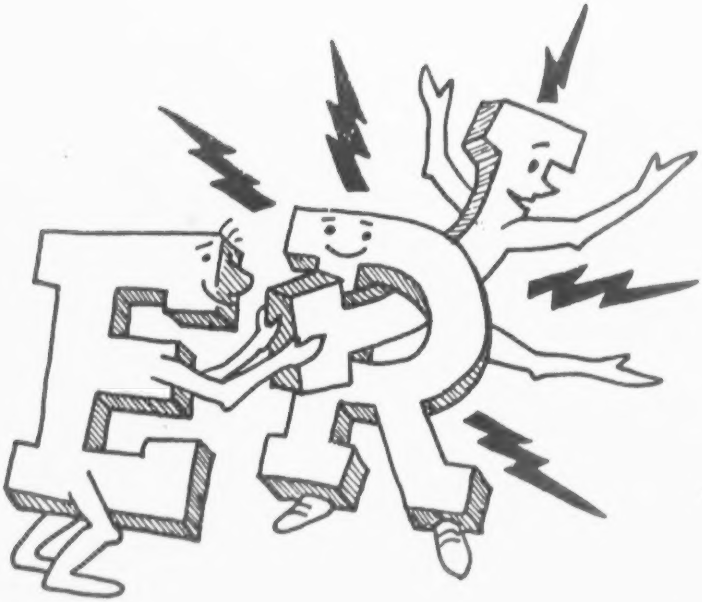

E
(VOLTS)
I
(AMPERES)
R
(OHMS)

$$E = IR$$

$$I = \frac{E}{R}$$

$$R = \frac{E}{I}$$

Ohm's Law



One volt is required to push one amp through one ohm resistance.

$$E = IR$$

Volts = Amperes x Ohms

SELECTED INSTRUCTIONAL ACTIVITIES

1. Discuss the charge of an electron - - how it relates to current, electric field of static charge, and the volt unit of potential difference, as well as the practical units of measure for each. (E 1.4.1 through E 1.4.3)
2. Discuss the common methods of producing electricity. (E 1.4.4)
3. Discuss conventional current versus electron flow. (E 1.4.5)
4. Demonstrate the solution of Ohm's law for any of three (3) variables in terms of the other variables. (E 1.4.6)
5. Demonstrate the use of Ohm's law in a simple D.C. circuit. (E 1.4.7)
6. Give students several circuits to practice using Ohm's law. (E 1.4.7)
7. Discuss the relationship between power and energy and the practical unit of measure for each. (E 1.4.8)
8. Discuss the power dissipated in a resistor and how the power formula is used. (E 1.4.9)
9. Discuss electrical shock hazard and the safety rules. (E 1.4.10)

SELECTED TOOLS AND MATERIALS

Ohm's law worksheets
Problems for unknown voltage, resistance, and amperage
Memory wheel
Overhead projector

SELECTED AUDIOVISUAL MATERIALS

"Ohm's Law" (transparency)
"Ohm's Law Magic Circle" (transparency)
"Ohm's Law - - Computing Current" (transparency)
"Ohm's Law - - Computing Resistance" (transparency)
"Ohm's Law - - Computing Power Memory Wheel" (transparency)

SELECTED REFERENCES

Basic Electronics, 5th Edition. Bernard Grob. (Chapter 1)

Introductory Circuit Analysis, 4th Edition. Robert L. Boylestad. (Chapter 4)

DUTY AREA

PROGRAM

1. DEMONSTRATING D.C. KNOWLEDGE

TASK/COMPETENCY

COURSE

1.5 Measure resistance, current, and voltage drop in a D.C. resistive circuit

1.5

PERFORMANCE OBJECTIVE

P 1.5 Given a simple series D.C. circuit and the appropriate meters, measure the resistance of, current through, and voltage drop across each component of the circuit (while observing proper meter connections and safety practices) to within 1% of the instructor-measured value.

SELECTED ENABLING OBJECTIVES

E 1.5.1 Identify the operating controls and write the function of each control of an electronic voltmeter (EVM) and volt-ohm-ammeter (VOM).

E 1.5.2 Identify each of the leads of an EVM and a VOM.

E 1.5.3 Measure voltage and resistance values at specified points on each of the voltage and resistance ranges of an EVM and VOM.

E 1.5.4 Connect a current meter and measure the direct current in a circuit.

E 1.5.5 Measure the effects of resistance in controlling current in a circuit.

E 1.5.6 Measure the effects of voltage in controlling current in a circuit.

E 1.5.7 Identify the safety precautions that must be observed when measuring voltage, current, and resistance in a circuit.

E 1.5.8 Explain loading effects of a voltmeter and insertion effects of an ammeter.

CRITERION-REFERENCED MEASURE

C 1.5 Measure the resistance of, current through, and voltage drop across each component of the circuit (while observing proper meter connections and safety practices) to within 1% of instructor's measured values.

SELECTED INSTRUCTIONAL ACTIVITIES

1. Review simple series circuits. (E 1.5.1)
2. Explain the functions and demonstrate the proper use of the following:
   A. Ohm meter
   B. Volt meter
   C. Ammeter
   D. Multimeter (VOM, VTVM, FET, digital) (E 1.5.1 through E 1.5.7)
3. Emphasize the proper safety procedures in all of the above. (E 1.5.3 through E 1.5.7)
4. Have students conduct an experiment on electronic voltmeter familiarization. (E 1.5.1, E 1.5.2, E 1.5.3, and E 1.5.5)
5. Have students conduct an experiment on resistance color code and use of ohmmeters. (E 1.5.1 through E 1.5.3)
6. Have students conduct an experiment on direct current measurements and control of current. (E 1.5.4 through E 1.5.6)
7. Explain voltmeter loading effect and ammeter insertion effect. (E 1.5.8)

SELECTED TOOLS AND MATERIALS

Ammeters
Ohm meters
Leads
Bread boards
Selected resistors
Potentiometer

Voltmeters
Multimeters or Ammeters
Power source (Low voltage D.C.)
Hook-up wire
Single-pole-simple throw switch (SPST)

SELECTED AUDIOVISUAL MATERIALS

"Basic Electricity and Electronics: Director Current" (filmstrip/cassette), Bergwall Productions

SELECTED REFERENCES

Basic Electronics, 5th Edition. Bernard Grob. (Chapter 8)

Introductory Circuit Analysis, 4th Edition. Robert L. Boylestad. (Chapter 5)

Basic Electricity: A Text-Lab Manual, 5th Edition. Paul B. Zbar. (Experiments 1, 2, and 6)

DUTY AREA

DEMONSTRATING D.C. KNOWLEDGE

PROGRAM

TASK/COMPETENCY

1.6 Analyze the relationship between R and I in a resistor

COURSE

1.6

PERFORMANCE OBJECTIVE

P 1.6 Given a variable D.C. power supply, several resistors (both fixed and variable), an ammeter and a volt ohm ammeter, construct a series circuit and prove I is inversely proportional to R when voltage is held constant; all calculated values must be within ± 10% of the instructor-measured value.

SELECTED ENABLING OBJECTIVES

E 1.6.1 Use Ohm's law to calculate current I in a series resistive circuit.

E 1.6.2 Explain the relationship between voltage, current, and resistance in resistive circuits.

E 1.6.3 Use a volt ohm ammeter to measure voltage, amperage, and resistance in a circuit.

E 1.6.4 Demonstrate safe procedures in connecting and disconnecting power supplies and measurement instruments.

E 1.6.5 Construct a series resistive circuit.

E 1.6.6 Identify at least three (3) measurement errors that must be considered in attempting to establish the accuracy of a measurement.

E 1.6.7 Define:

A. Open circuit, and
B. Short circuit.

CRITERION-REFERENCED MEASURE

C 1.6 Construct a series circuit and prove I is inversely proportional to R when voltage is held constant; all calulated values must be within ±10% of the measured value.

SELECTED INSTRUCTIONAL ACTIVITIES

1. Review Ohm's law. (E 1.6.1 and E 1.6.2)
2. Review the safety procedures used when connecting and disconnecting power supplies and measurement instruments. (E 1.6.4)
3. Demonstrate procedures used to measure voltage, current, and resistance in a circuit.
4. Review the function, range, and special function switches found on VOM's. (E 1.6.3)
5. Demonstrate the construction of a series resistive circuit. (E 1.6.5)
6. Have students conduct an experiment to determine the mathematical relationship between current I in a resistor, and the voltage V across the resistor. (E 1.6.3 through E 1.6.5)
7. Discuss measurement errors and their possible sources. (E 1.6.6)
8. Discuss open and short circuits and their effects on the circuit current. (E 1.6.7)

SELECTED TOOLS AND MATERIALS

Variable D. C. power supply
Bread boards
Meters (volt meter, ammeter, VOM), and leads
Hook-up wire
Selected resistors
Potentiometer
SPST switch

SELECTED AUDIOVISUAL MATERIALS

"Electricity and Electronics: Direct Current" (filmstrip), Bergwall Productions

SELECTED REFERENCES

Basic Electronics, 5th Edition. Bernard Grob. (Chapter 3)

Basic Electricity: A Text-Lab Manual, 5th Edition. Paul B. Zbar. (Experiment 7)

DUTY AREA

1. DEMONSTRATING D.C. KNOWLEDGE

PROGRAM

TASK/COMPETENCY

1.7 Identify series circuit characteristics

COURSE

1.7

PERFORMANCE OBJECTIVE

P 1.7 Given a functional series circuit, necessary formulas, and a multimeter, identify five (5) series circuit characteristics without error.

SELECTED ENABLING OBJECTIVES

E 1.7.1 Draw a schematic drawing of a series circuit consisting of three (3) resistors, an on-off switch, and a voltage source; label all components.

E 1.7.2 State briefly a rule for determining polarity of the voltage drop across each resistor in a series circuit.

E 1.7.3 Prove that if $V_T=V_1+V_2+V_3$, then $R_T=R_1+R_2+R_3$.

E 1.7.4 Derive the formula $P_T=P_1+P_2+P_3$ from the fact that $V_T=V_1+V_2+V_3$.

E 1.7.5 State briefly why the largest R in a series circuit dissipates the most power.

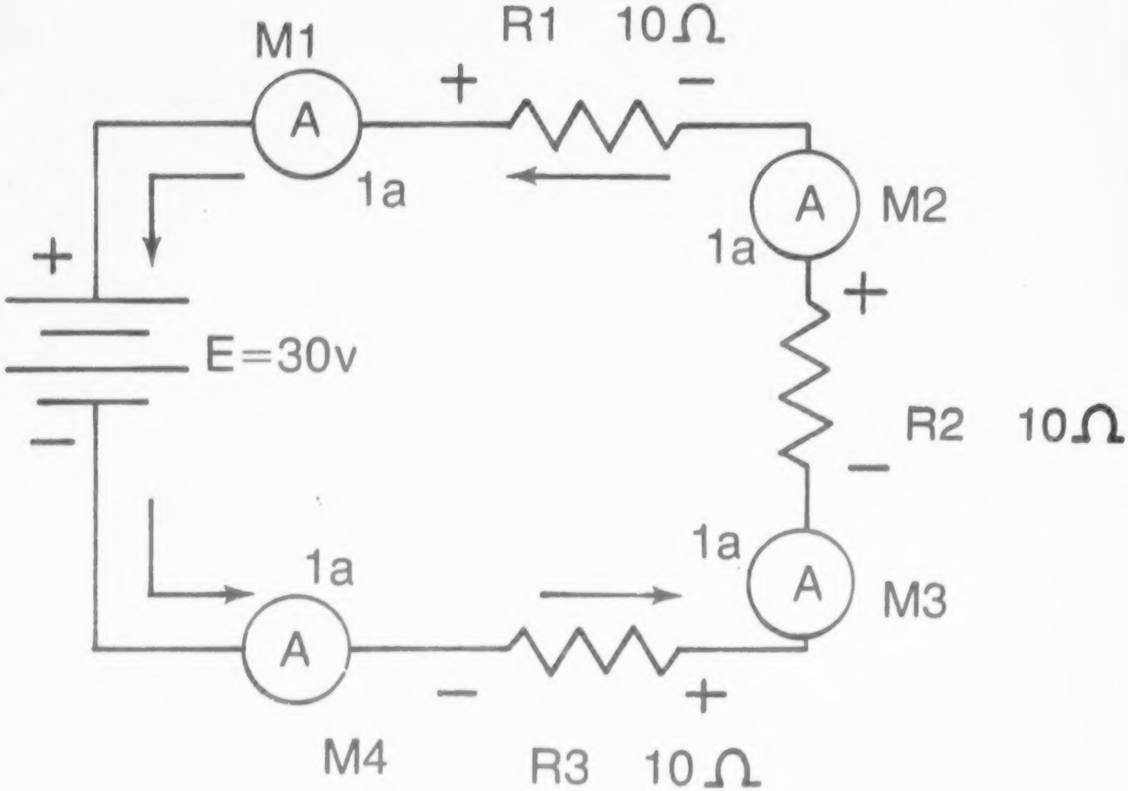
E 1.7.6 Determine experimentally the characteristics of a series resistive circuit.

E 1.7.7 List the characteristics of a series resistive circuit.

CRITERION-REFERENCED MEASURE

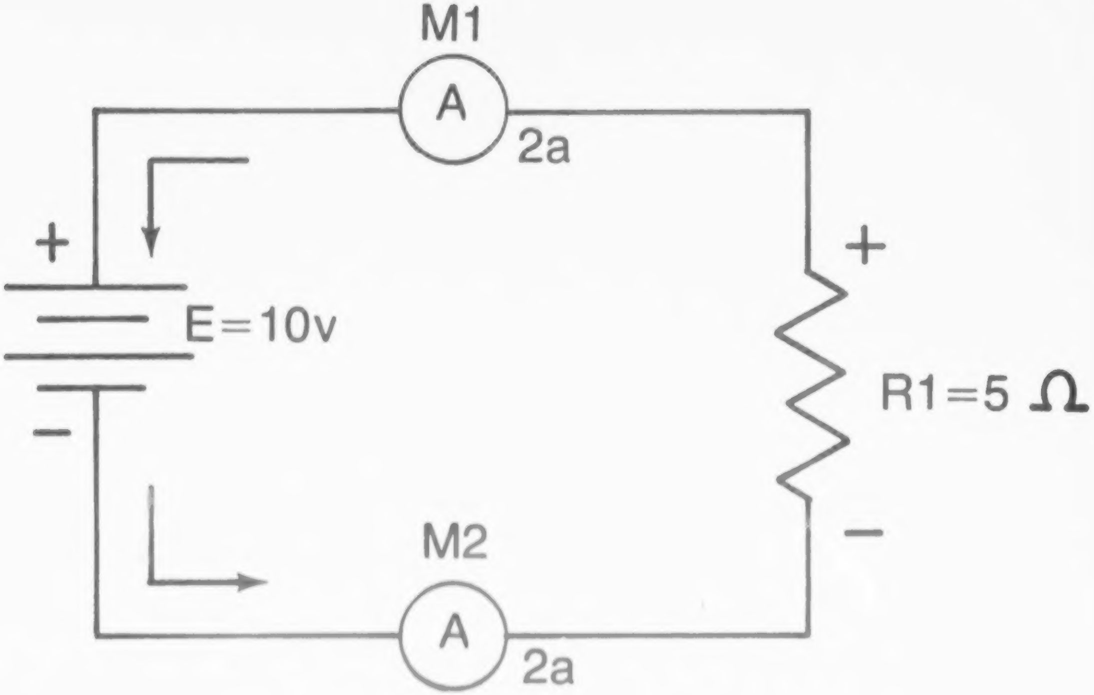
C 1.7 Identify five (5) series circuit characteristics without error.

Combined Series Circuit


M1
R1 10Ω
+
−
A
1a
A
M2
1a
+
+
E=30v
−
R2 10Ω
−
1a
A
M3
1a
A
−
+
M4
R3 10Ω

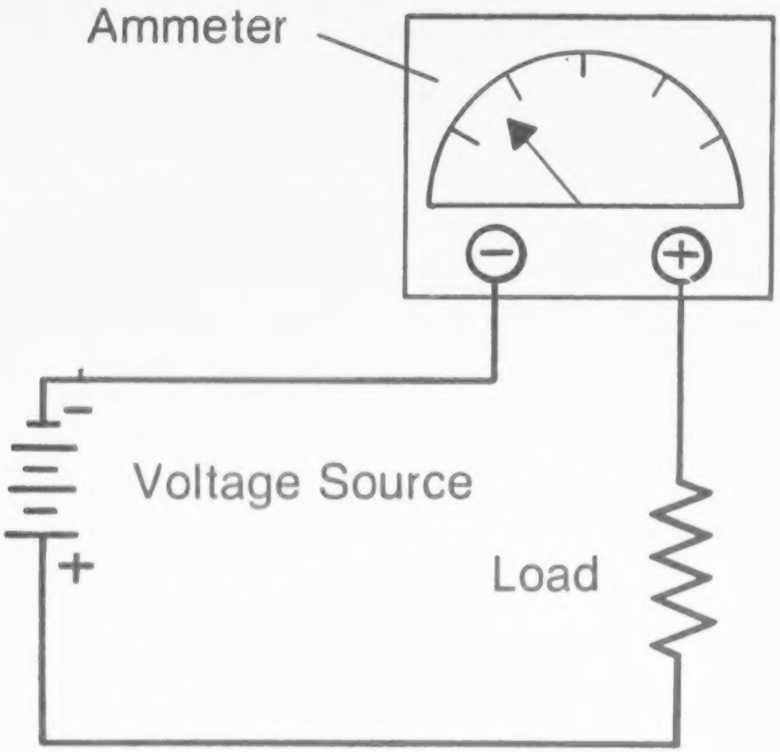
Current measured by M1 will equal that of M2, M3 or M4.

Simple Series Circuit

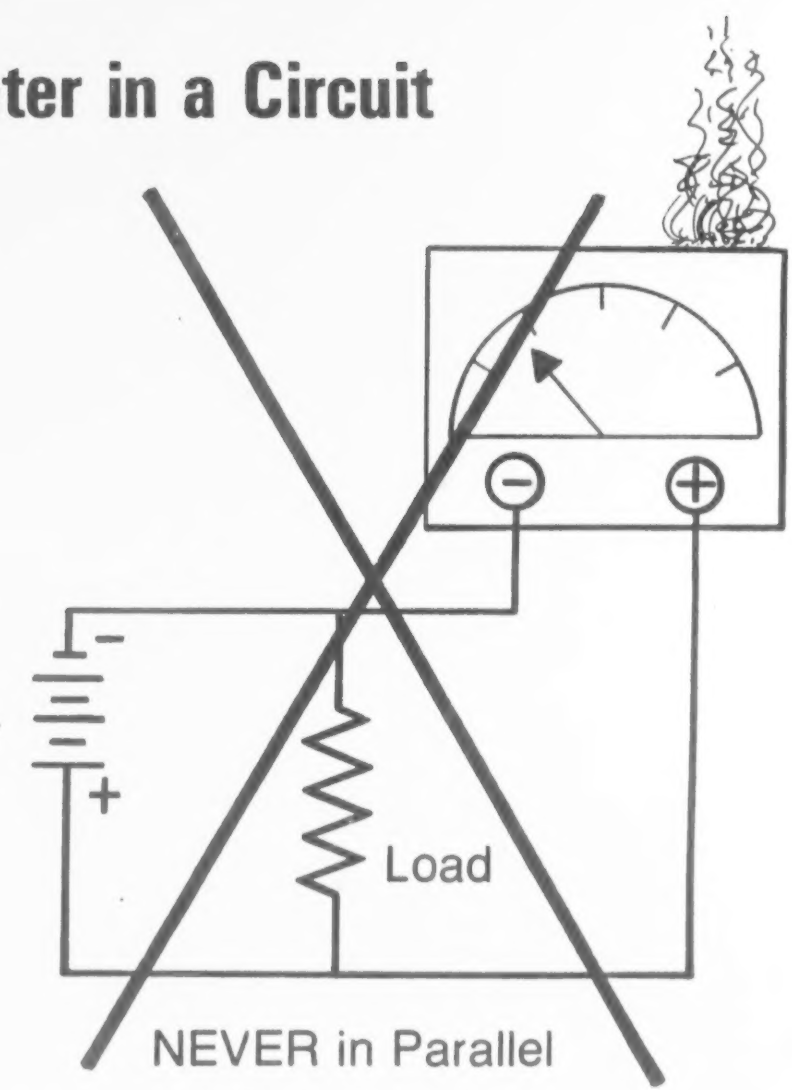

M1
A
2a
+
E=10v
–
+
R1=5 Ω
–
M2
A
2a

Current measured by M1 will equal that of M2.

Using the Ammeter in a Circuit

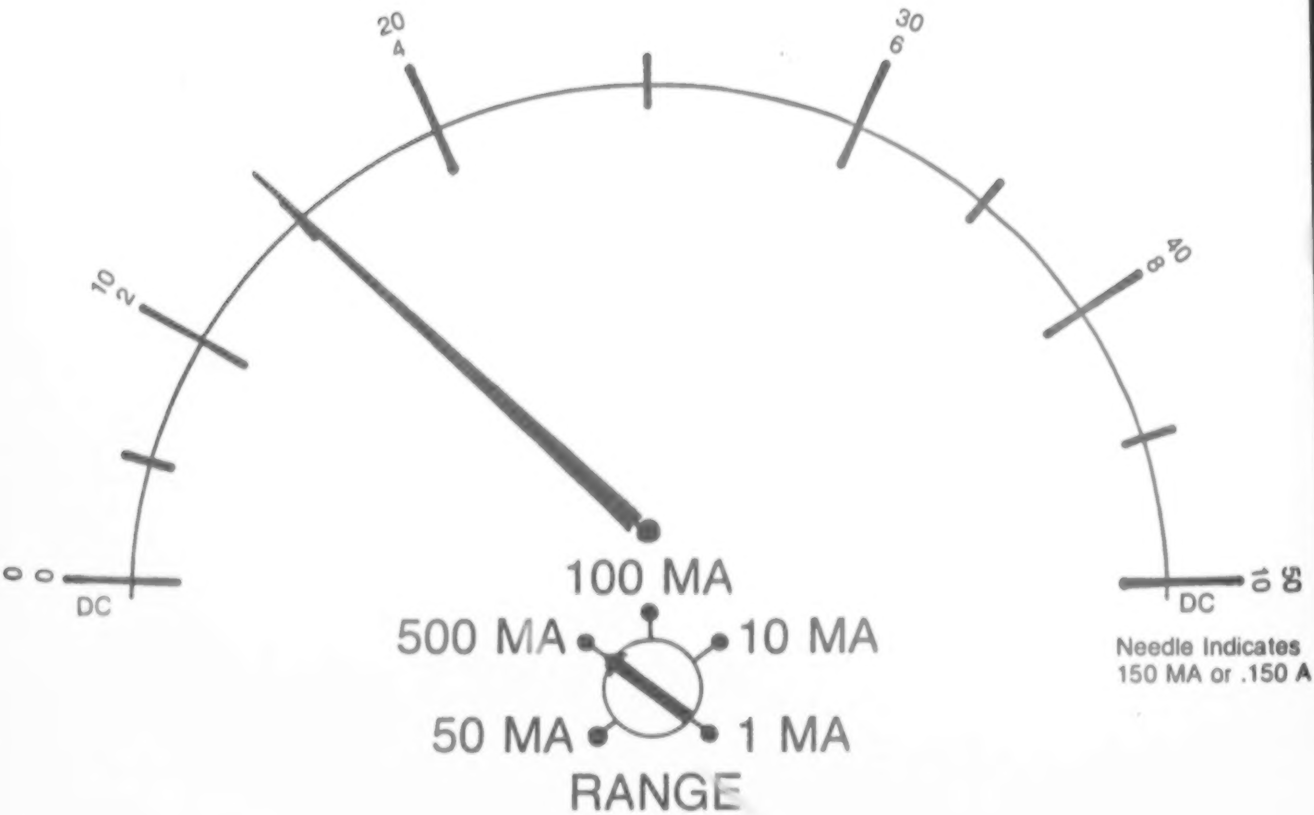

Ammeter
Voltage Source
Load

Ammeter should be in series with load



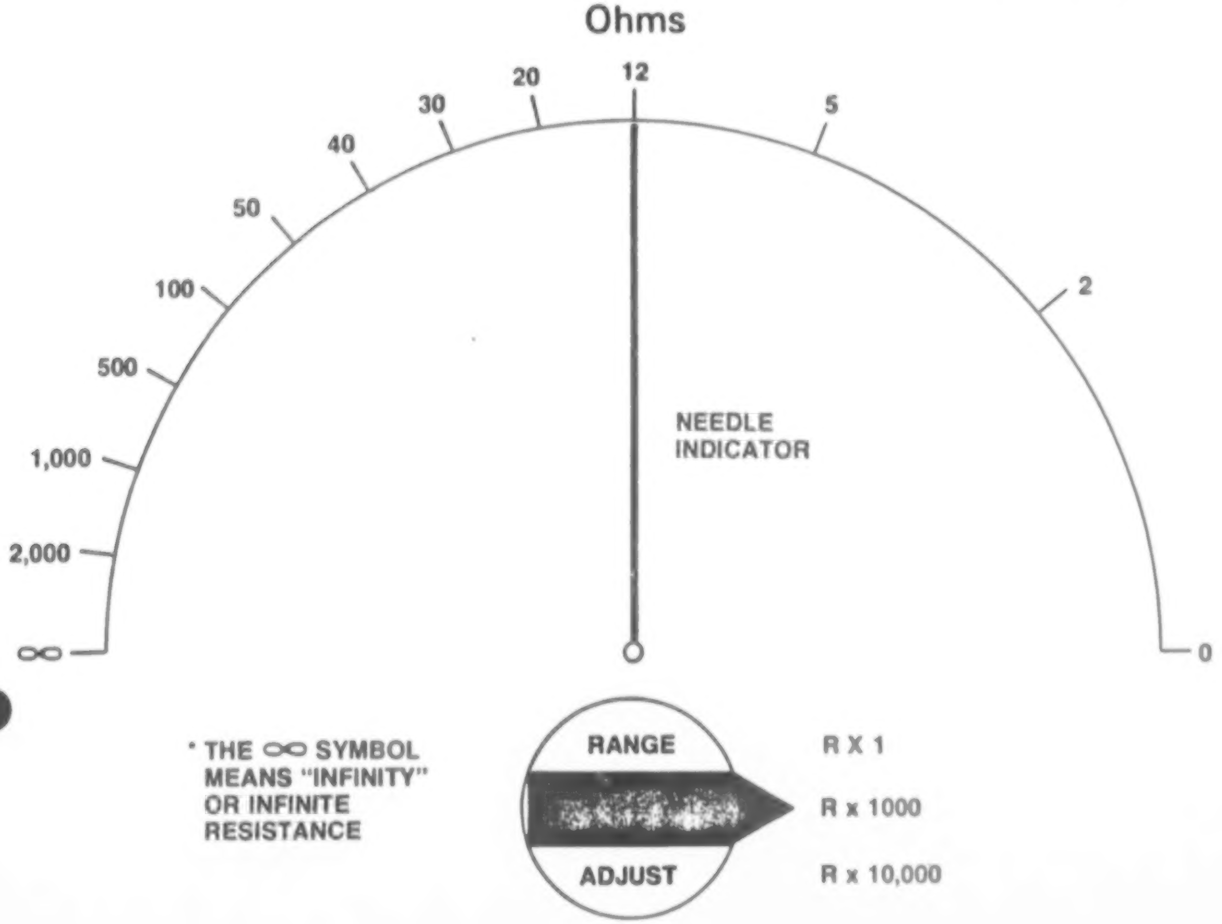
NEVER in Parallel

DC Current Scale and Range Switch on Typical Ammeter



0
0
DC
10
2
20
4
30
6
40
8
50
10
DC
100 MA
500 MA
10 MA
50 MA
1 MA
RANGE
Needle Indicates
150 MA or .150 A

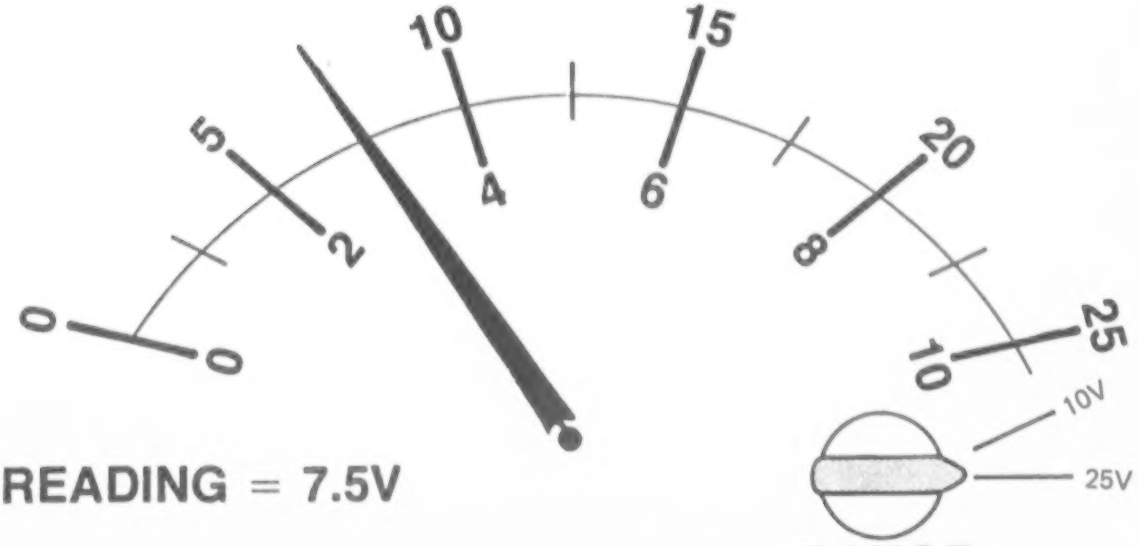
Ohmmeter Scale and Range Settings


Ohms
∞
2,000
1,000
500
100
50
40
30
20
12
5
2
0
NEEDLE
INDICATOR
RANGE
ADJUST
R X 1
R x 1000
R x 10,000

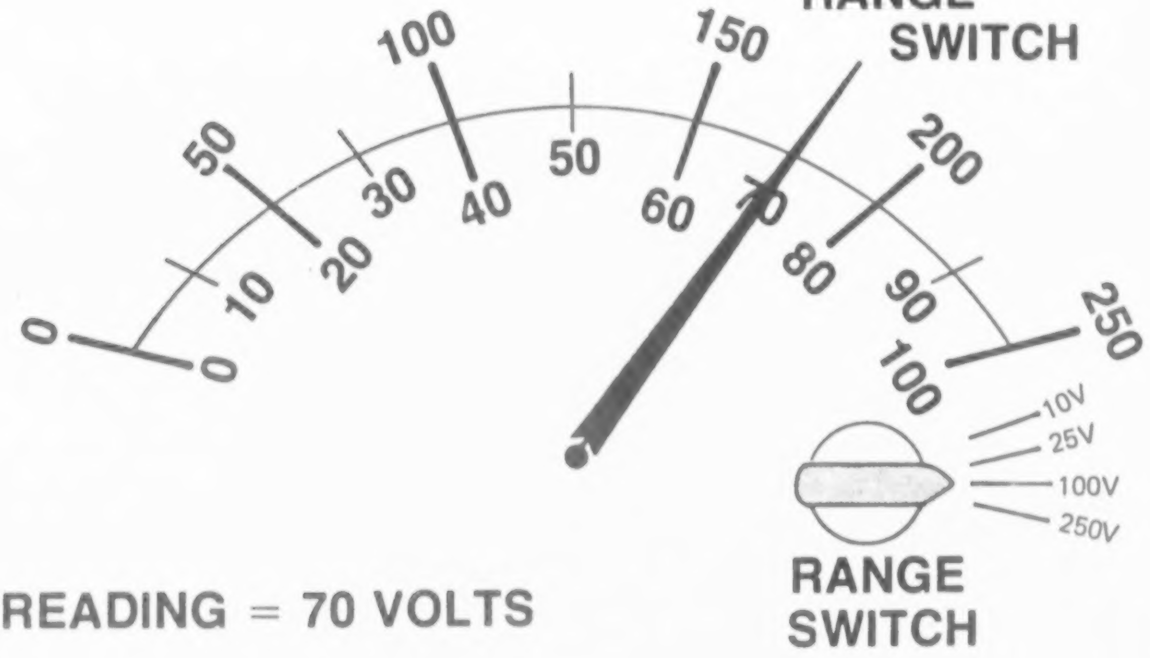
* THE ∞ SYMBOL MEANS "INFINITY" OR INFINITE RESISTANCE

WITH RANGE ADJUST SET ON	METER INDICATION IS			
R x 1	12 x 1	or	12	Ohms
R x 100	12 x 1,000	or	12,000	Ohms
R x 10,000	12 x 10,000	or	120,000	Ohms

VOLTMETER SCALES AND RANGE SETTINGS


0
5
10
15
20
25
0
2
4
6
8
10
10V
25V
RANGE
SWITCH

READING = 7.5V


0
50
100
150
200
250
0
10
20
30
40
50
60
70
80
90
100
10V
25V
100V
250V
RANGE
SWITCH

READING = 70 VOLTS

SELECTED INSTRUCTIONAL ACTIVITIES

1. Demonstrate the selection and reading of the correct scales on the multimeter. (E 1.7.6)
2. Demonstrate the proper hook-up procedure in a series circuit to correctly measure current, resistance, and voltage drop. (E 1.7.6)
3. Demonstrate the proper method to connect the power source in a series circuit. (E 1.7.6)
4. Demonstrate how Ohm's law applies to a series circuit. (E 1.7.3 through E 1.7.6).
5. Demonstrate series resistance addition formulas. (E 1.7.3, through E 1.7.6)
6. Discuss series circuit characteristics in terms of how:
    1. R_T equals the sum of all resistors,
    2. I equals I_T at any point in the circuit,
    3. The sum of the voltage drops across the circuit components equals the source voltage, and
    4. There is only one path for current flow. (E 1.7.3, through E 1.7.7)
7. Have the students conduct an experiment on a series circuit to determine the characteristics of a series resistive circuit. (E 1.7.6 and E 1.7.7)
8. Demonstrate the technique used to draw a series circuit containing several resistors, an on-off switch, and a voltage source. (E 1.7.1)
9. Discuss rules for determining the polarity of the voltage drop across resistors in a series circuit. (E 1.7.2)

SELECTED TOOLS AND MATERIALS

Multimeter and leads
Six different values of resistors
Bread board
Hook-up wire
D. C. power supply (regulated variable)
Wire strippers
SPST switch
Overhead projector

SELECTED AUDIOVISUAL MATERIALS

"Voltmeter Scales and Range Settings" (transparency)
"Ohmmeter Scale and Range Settings" (transparency)
"D. C. Current Scale and Range swtich on Typical Ammeter" (transparency)
"Using an Ammeter in a Circuit" (transparency)
"Memory Wheel for Solving Problems" (transparency) [located under task 4.1]
"Simple Series Circuit" (transparency)
"Combined Series Circuit" (transparency)
"Electricity and Electronics: Direct Current" (filmstrip), Bergwall Productions

SELECTED REFERENCES

Basic Electronics, 5th Edition. Bernard Grob. (Chapter 3)

Introductory Circuit Analysis, 4th Edition. Robert L. Boylestad. (Chapter 5)

Basic Electricity: A Text-Lab Manual, 5th Edition. Paul B. Zbar. (Experiment 8)

DUTY AREA

1. DEMONSTRATING D.C. KNOWLEDGE

PROGRAM

TASK/COMPETENCY

1.8 Identify parallel circuit characteristics

COURSE

1.8

PERFORMANCE OBJECTIVE

P 1.8 Given a functional parallel circuit, necessary formulas and a multimeter, identify five (5) parallel circuit characteristics without error.

SELECTED ENABLING OBJECTIVES

E 1.8.1 Draw a schematic drawing of a parallel circuit consisting of three (3) resistors, an on-off switch, and a voltage source; label all components.

E 1.8.2 Prove that if $1/R_T = 1/R_1 + 1/R_2$ then $R_T = R_1 + R_2/(R_1 + R^2)$.

E 1.8.3 Show how to connect three (3) equal resistors for a combined equivalent resistance of 1/3 the value of one (1) resistor.

E 1.8.4 Explain why the current increases in the voltage source as more parallel branches are added to the circuit.

E 1.8.5 State briefly why the total power equals the sum of the individual values of power, whether a series circuit or a parallel circuit is used.

E 1.8.6 Determine experimentally that the total current I_T in a circuit containing resistors connected in parallel is:

A. Greater than the current in any branch, and
B. Equal to the sum of the currents.

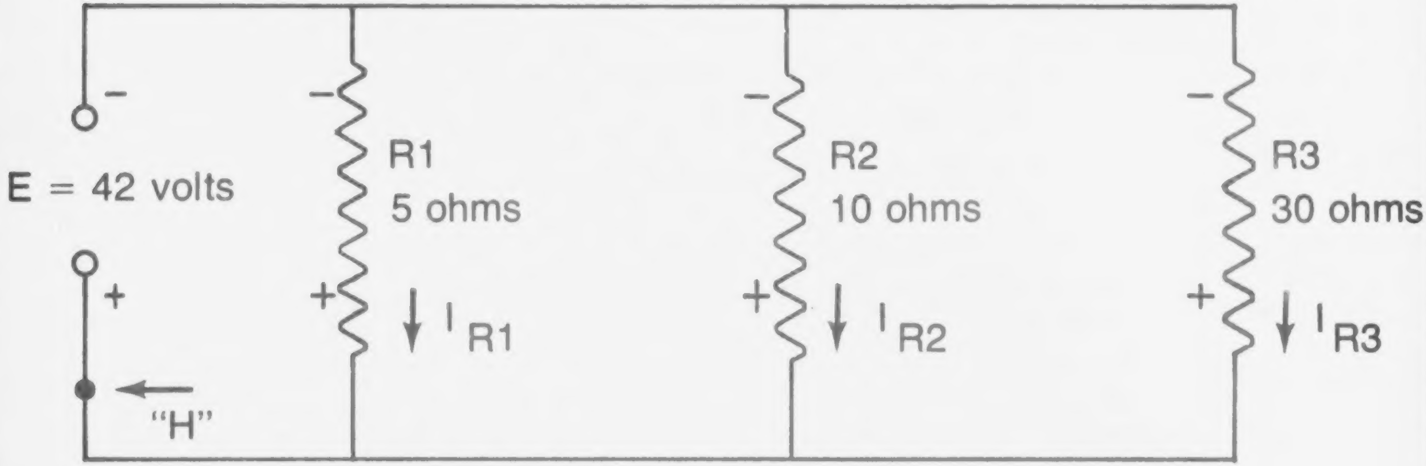
E 1.8.7 Determine experimentally that the total resistance R_T of resistors connected in parallel is given by the formula: $1/R_T = 1/R_1 + 1/R_2 + 1/R_3 + \ldots$

E 1.8.8 Design and construct a parallel circuit which will meet specified voltage, current, and resistance requirements and check, by measurements, the design parameters.

CRITERION-REFERENCED MEASURE

C 1.8 Identify five (5) parallel circuit characteristics without error.

Finding Current in a Parallel Circuit

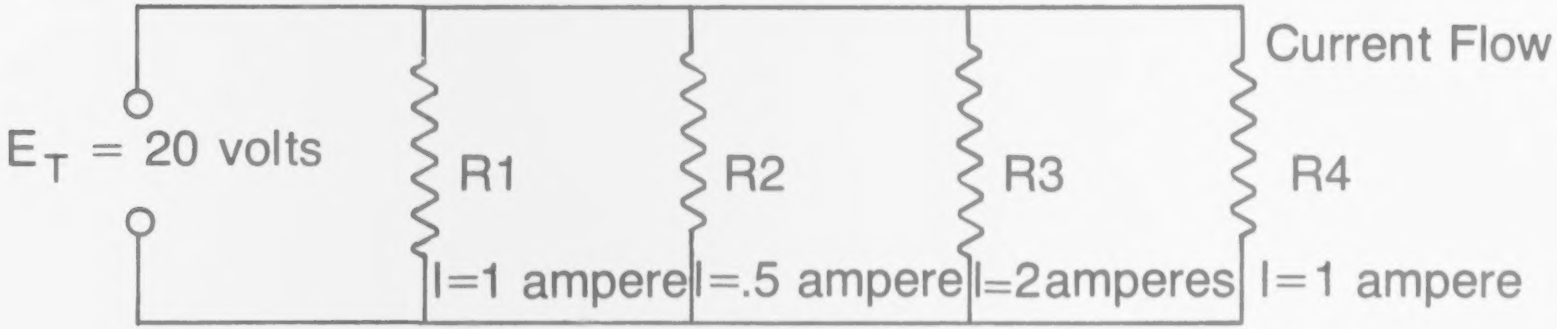

−
E = 42 volts
+
"H"
−
R1
5 ohms
+
I_{R1}
−
R2
10 ohms
+
I_{R2}
−
R3
30 ohms
+
I_{R3}

I_T =__________(Amperes)

How much current is passing through point "H" in this circuit? There are two methods for determining total current in this circuit:

1. Find the current flowing through each branch (ex.: $I_{R1} = \frac{E}{R1}$), then add all 3 branch currents ($I_T = I_{R1} + I_{R2} + I_{R3}$).
2. Find the total resistance using the reciprocal resistance formula, then calculate total current ($I_T = \frac{E}{R_T}$).

Finding the Total Resistance in Parallel Circuits


Current Flow
$E_T = 20$ volts
R1
R2
R3
R4
I=1 ampere
I=.5 ampere
I=2amperes
I=1 ampere

$$R_T = \frac{E_T}{I_T} = \frac{20}{4.5} = 4.4 \text{ ohms}$$

$$R1 = \frac{20 \text{ volts}}{1 \text{ ampere}} = 20 \text{ ohms}$$

$$R2 = \frac{20 \text{ volts}}{.5 \text{ ampere}} = 40 \text{ ohms}$$

$$R3 = \frac{20 \text{ volts}}{2 \text{ amperes}} = 10 \text{ ohms}$$

$$R4 = \frac{20 \text{ volts}}{1 \text{ ampere}} = 20 \text{ ohms}$$

$$\frac{1}{R_T} = \frac{1}{R1} + \frac{1}{R2} + \frac{1}{R3} + \frac{1}{R4}$$

$$\frac{1}{R_T} = \frac{1}{20} + \frac{1}{40} + \frac{1}{10} + \frac{1}{20}$$

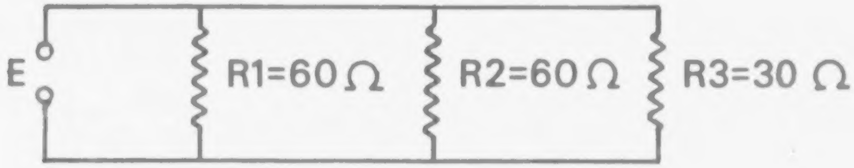
$$\frac{1}{R_T} = \frac{2 + 1 + 4 + 2}{40} = \frac{9}{40}$$

$$R_T = \frac{40}{9} = 4.4 \text{ ohms}$$

The Reciprocal Resistance Method

For Calculating Total Resistance

in a Parallel Circuit: $1/R_T = 1/R1 + 1/R2 + 1/R3$



Step 1: Find Least Common Denominator and Add the Reciprocals:

$$\frac{1}{60} = \frac{1}{60}$$

$$\frac{1}{60} = \frac{1}{60}$$

$$\frac{1}{30} = \frac{2}{60}$$

$$\frac{4}{60} \text{ Total}$$

Step 2: Invert the Reciprocals:

$$\frac{1}{R_T} = \frac{4}{60}$$

$$R_T = \frac{60}{4}$$

Step 3: Solve For R_T:

$$R_T = 15\Omega$$

Resistance in Parallel Circuits

The reciprocal of the total resistance of a parallel circuit is equal to the sum of the reciprocals of the individual resistances

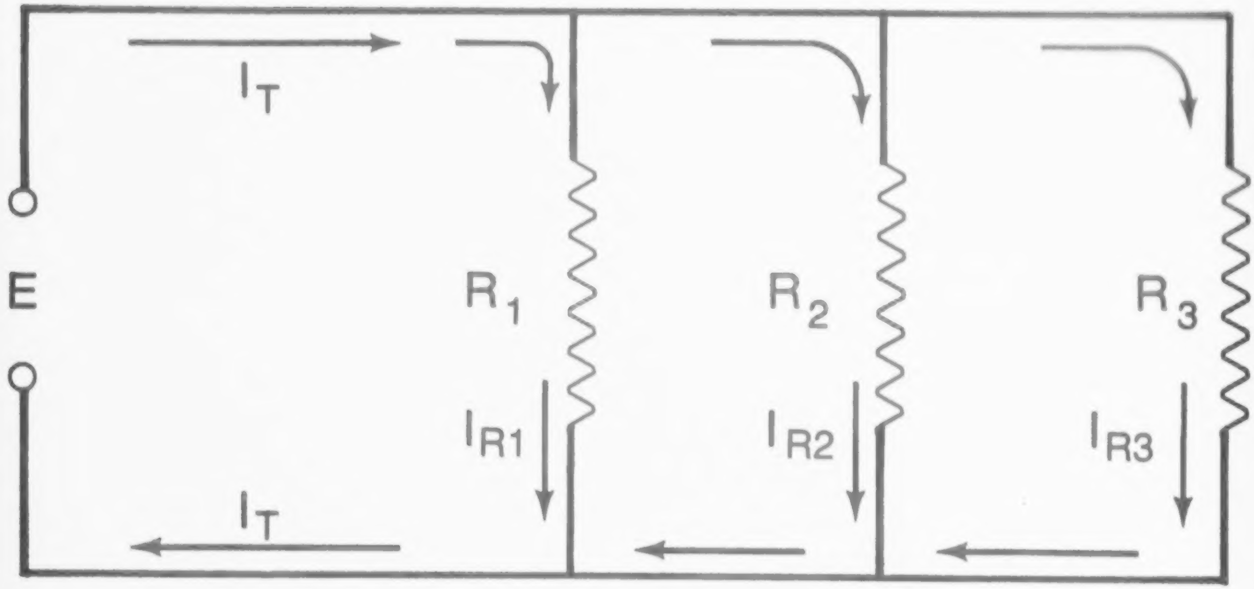
or

$$\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \frac{1}{R_4} + \frac{1}{R_5} + \cdots$$

or

$$R_T = \frac{1}{\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \frac{1}{R_4} + \frac{1}{R_5} + \ldots}$$

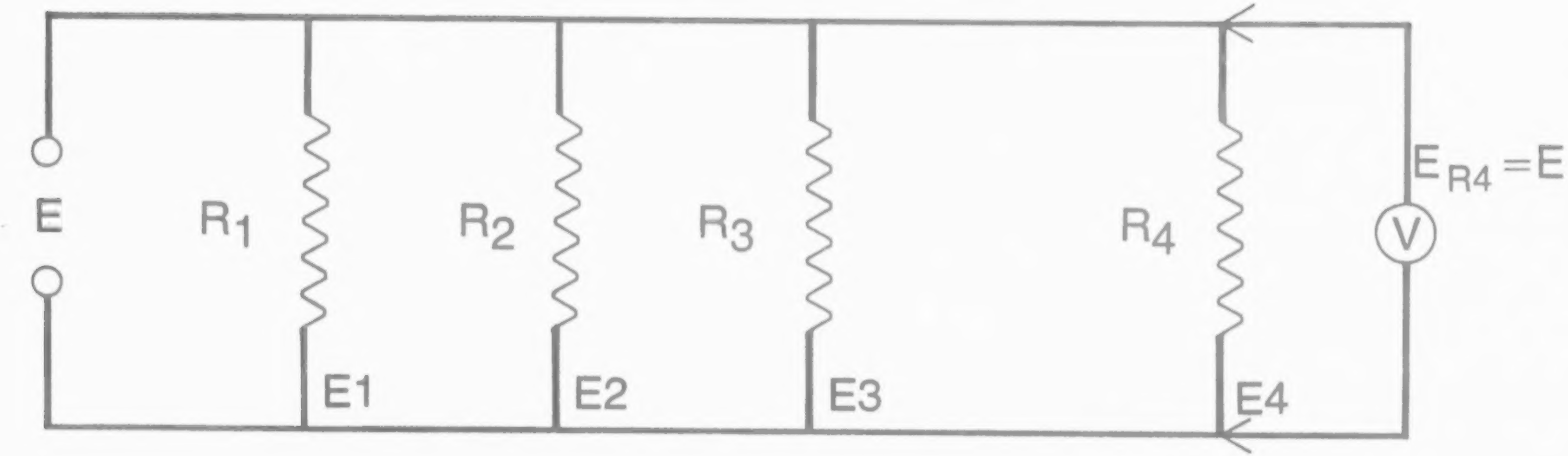
Current Flow in a Parallel Circuit


I_T
E
R_1
R_2
R_3
I_{R1}
I_{R2}
I_{R3}
I_T

The total current flowing through a parallel circuit is the sum of the currents flowing through each branch.

In the above circuit: $I_T = I_{R1} + I_{R2} + I_{R3}$

Voltage in a Parallel Circuit


E
R1
R2
R3
R4
E1
E2
E3
E4
V
E R4 = E

The voltage across each branch of a parallel circuit is the same value.

or

$$E = E1 = E2 = E3 = \ldots$$

SELECTED INSTRUCTIONAL ACTIVITIES

1. Review the selection and reading of the correct scales on the multimeter. (E 1.8.6 and E 1.8.7)
2. Demonstrate VOM hook-up procedures for parallel circuits to measure current, resistance, and voltage drop. (E 1.8.6 and E 1.8.7)
3. Demonstrate the technique used to draw a schematic of a parallel resistive circuit. (E 1.8.1)
4. Demonstrate how Ohm's law applies to a parallel circuit. (E 1.8.6)
5. Explain the parallel resistance addition formula. (E 1.8.2)
6. Have the students conduct an experiment to determine I_T in a parallel circuit. (E 3.8.6)
7. Discuss the characteristics of a parallel circuit. (E 1.8.1 through E 1.8.7)
8. Explain how power is calculated in a parallel circuit and how this calculation is the same for a series circuit. (E 1.8.5)
9. Have the students conduct an experiment to determine R_T in a parallel circuit. (E 1.8.7)
10. Have the students design and construct a parallel circuit for a specified voltage, current, and resistance requirements and check, by measurements, the design parameters. (E 1.8.8)

SELECTED TOOLS AND MATERIALS

Multimeter and leads
Three selected resistors
Bread board
Hook-up wire
D. C. power supply (regulated variable)
Wire strippers
SPST switch
Overhead projector

SELECTED AUDIOVISUAL MATERIALS

"Voltage in a Parallel Circuit" (transparency)
"Current in a Parallel Circuit" (transparency)
"Resistance in a Parallel Circuit" (transparency)
"The Reciprocal Resistance Method" (transparency)
"Finding Total Resistane in Parallel Circuits" (transparency)
"Finding Total Current in Parallel Circuits" (transparency)
"Basic Electricity and Electronics: Direct Current" (filmstrip), Bergwall Productions

SELECTED REFERENCES

Basic Electronics, 5th Edition. Bernard Grob. (Chapter 4)

Introductory Circuit Analysis, 4th Edition. Robert L. Boylestad. (Chapter 5)

Basic Electricity: A Text-Lab Manual, 5th Edition. Paul B. Zbar. (Experiments 11, 12, and 13)

DUTY AREA

1. DEMONSTRATING D.C. KNOWLEDGE

TASK/COMPETENCY

1.9 Identify series-parallel circuit characteristics

PROGRAM

COURSE

1.9

PERFORMANCE OBJECTIVE

P 1.9 Given a functional series-parallel circuit, necessary formulas and a multimeter, identify five (5) series/parallel circuit characteristics without error.

SELECTED ENABLING OBJECTIVES

E 1.9.1 Draw a schematic diagram showing two (2) resistors in parallel and in series with one (1) resistor and a voltage source.

E 1.9.2 Reduce several series-parallel circuits to an equivalent series circuit containing only one (1) resistor by redrawing the circuit each time two (2) resistors are combined into one (1).

E 1.9.3 Draw a circuit that shows an example of both positive and negative voltages with respect to ground.

E 1.9.4 Determine and verify experimentally the law for total resistance R_T of a series-parallel combination of resistors and that the voltage across each leg in a parallel circuit is the same as the total voltage across the parallel circuit.

E 1.9.5 Design a series-parallel network which will meet specified requirements.

E 1.9.6 Draw the schematic diagram of a Wheatstone Bridge circuit as two (2) series resistance strings connected in parallel, label each resistor as either R_X, R_S, R_1, R_2.

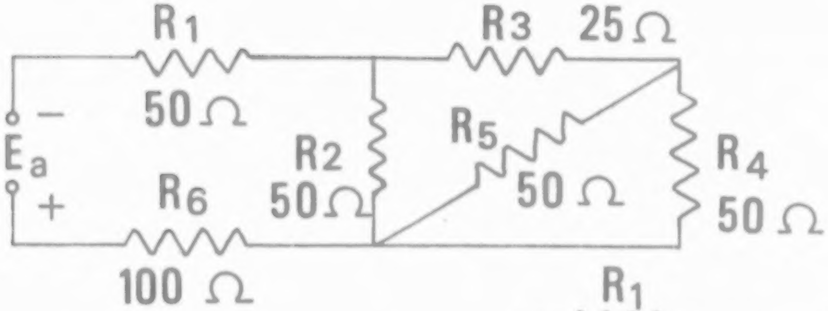
E 1.9.7 Prove that when the Wheastone Bridge is at balance, there will be no current flow through the galvanometer.

E 1.9.8 Work several problems for branch current, total current, total resistance, total power supplies by the source, and voltage drops in a series-parallel circuit.

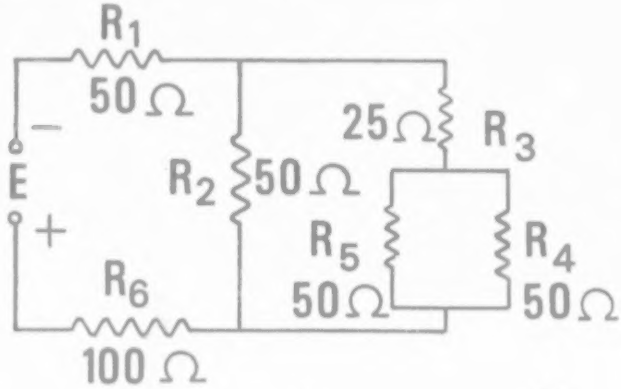
CRITERION-REFERENCED MEASURE

C 1.8 Identify five (5) series-parallel circuit characteristics without error.

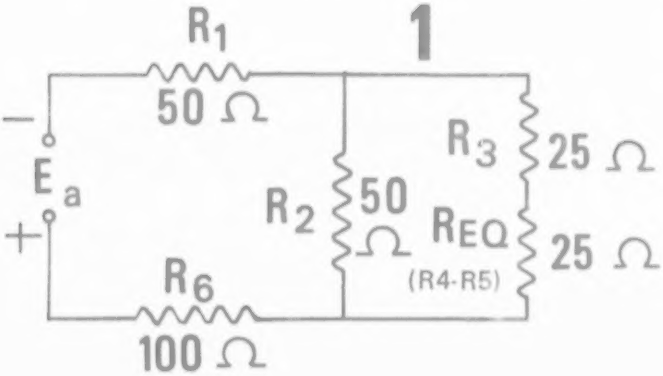
Circuit Reduction

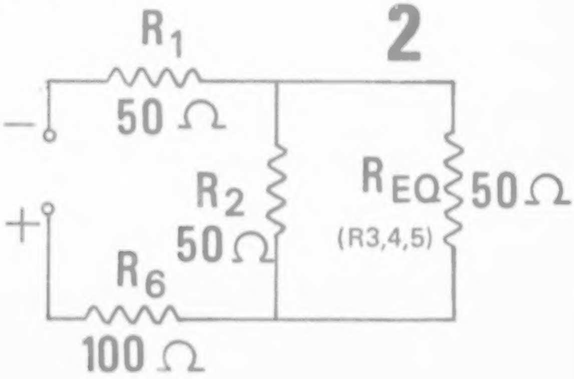

R1
50 Ω
R3 25 Ω
−
Ea
+
R2
50 Ω
R5
50 Ω
R4
50 Ω
R6
100 Ω

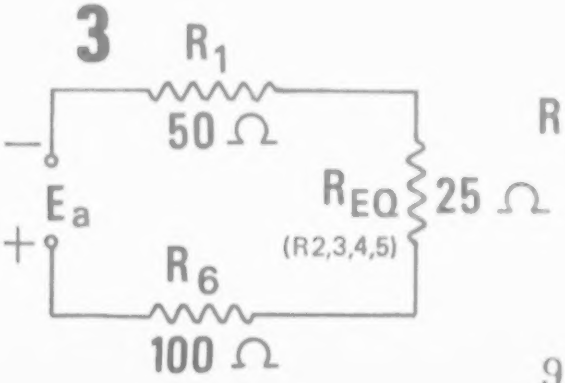
Step A: Trace Current Flow
and Re-Draw Circuit


R1
50 Ω
−
E
+
25 Ω R3
R2 50 Ω
R5
50 Ω
R4
50 Ω
R6
100 Ω

Step B: Reduce Circuit

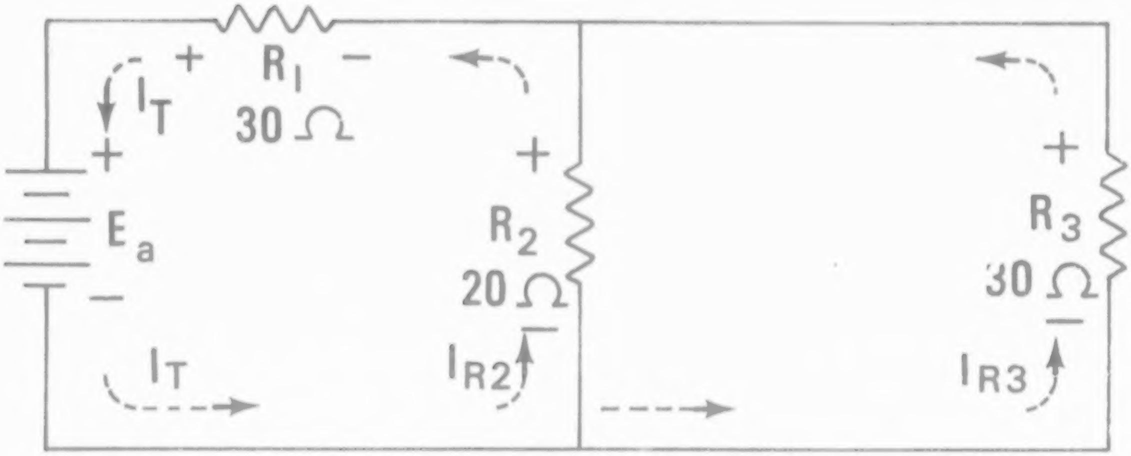

1
R1
50 Ω
−
Ea
+
R2 50 Ω
R3 25 Ω
REQ 25 Ω
(R4-R5)
R6
100 Ω


2
R1
50 Ω
−
+
R2
50 Ω
REQ 50 Ω
(R3,4,5)
R6
100 Ω

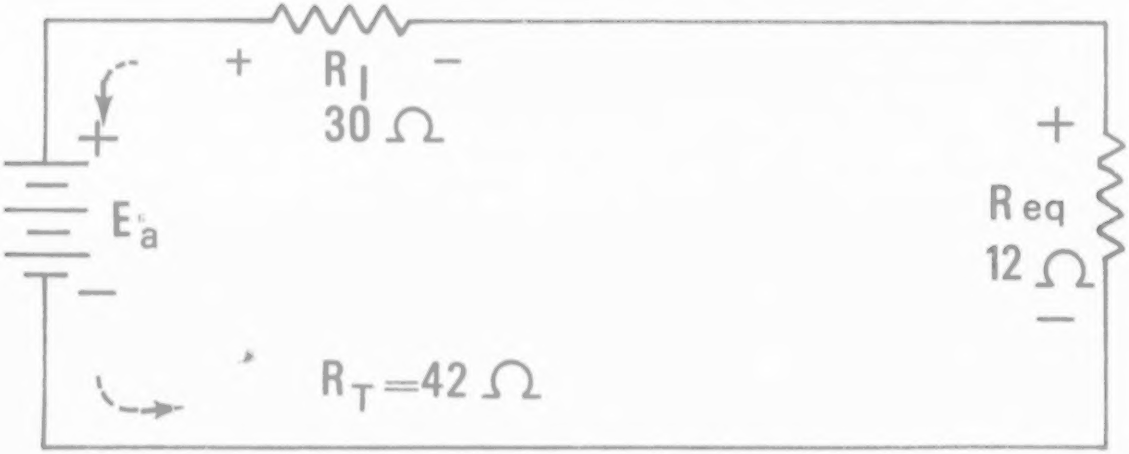

3
R1
50 Ω
−
Ea
+
REQ 25 Ω
(R2,3,4,5)
R6
100 Ω

$R_T = R_1 + R_{EQ} + R_6 = 175\ \Omega$

Series-Parallel Circuit and Equivalent Circuit

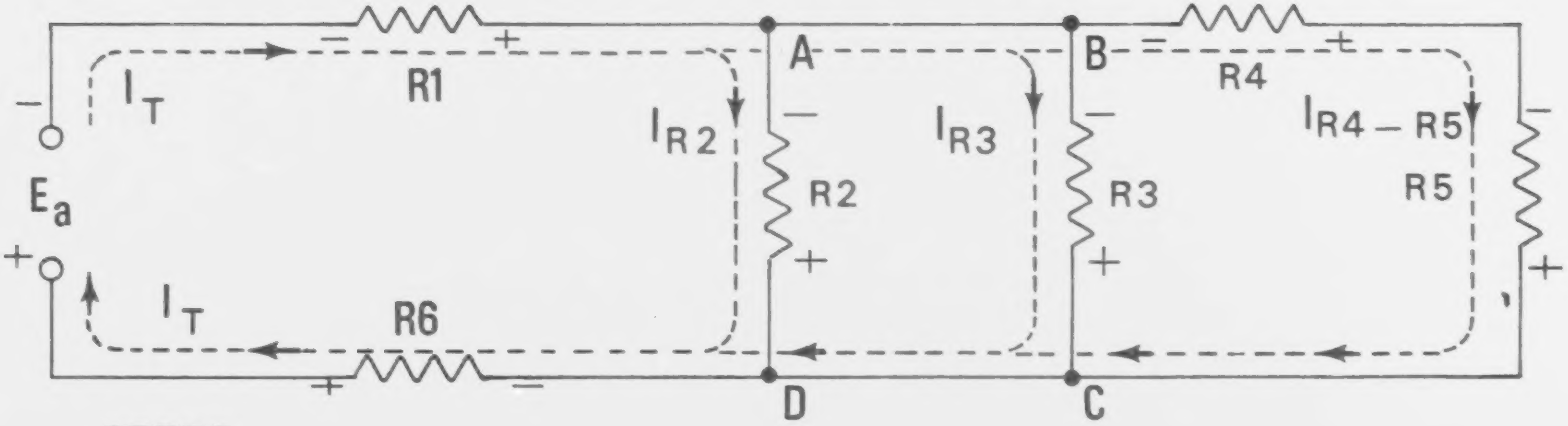

+ R1 −
30 Ω
IT
+
Ea
−
IT
+
R2
20 Ω
−
IR2
+
R3
30 Ω
−
IR3

Circuit


+ R1 −
30 Ω
+
Ea
−
+
Req
12 Ω
−
RT =42 Ω

Equivalent Circuit

Steps to Simplify a Series-Parallel Circuit

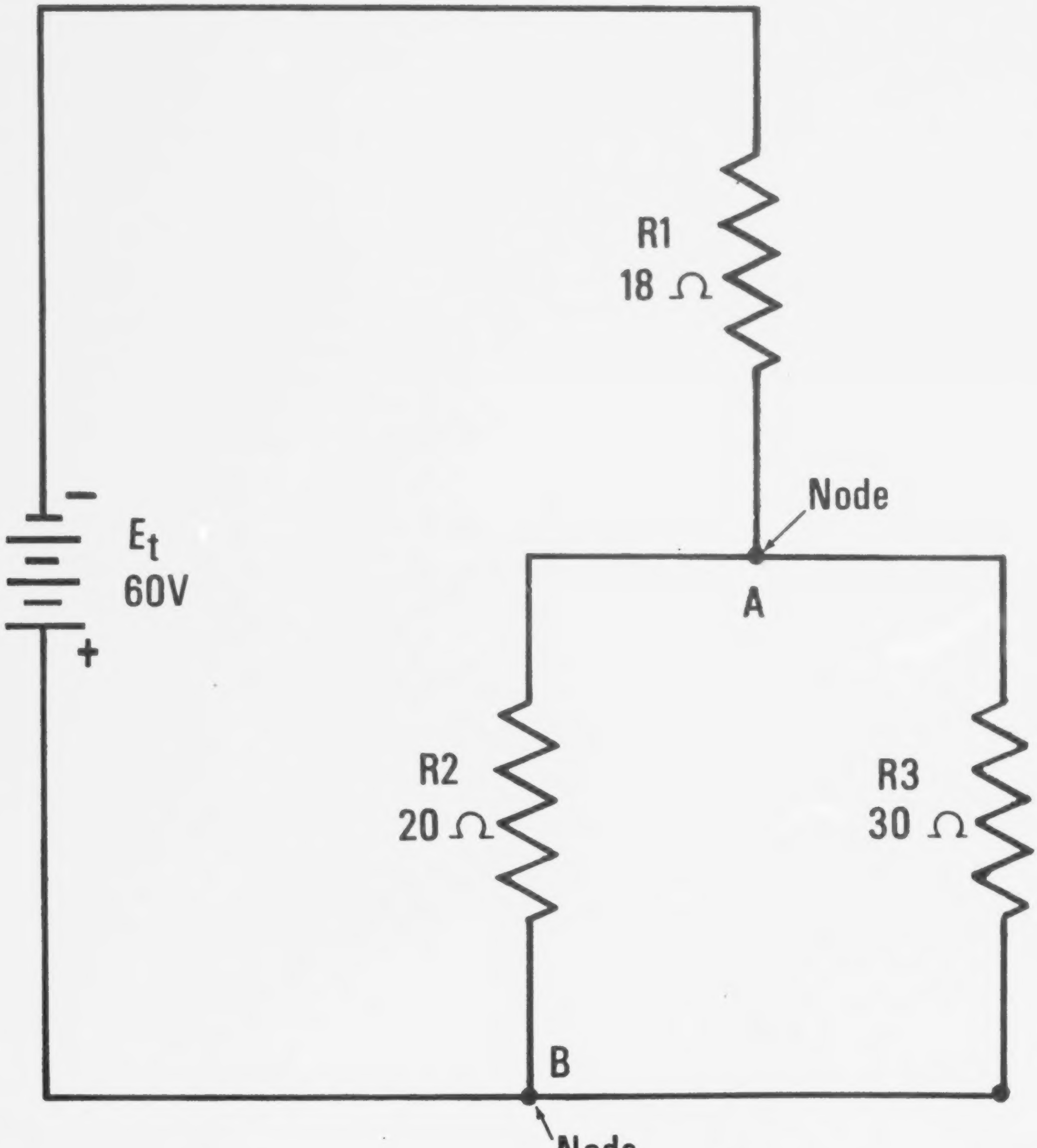


STEPS:

1. Trace Current Flow and Identify Voltage Drop Polarity (See Above)
2. Identify Nodes
   a. Current Division — A & B
   b. Current Return — C & D
3. Identify Resistors in Series With Ea: R1 & R6
4. Identify Resistors in Parallel: R2, R3, & (R4 + R5)
5. Identify Series-Parallel Resistors:
   a. R2, R3, & (R4 + R5) Become R_{eq} When the Reciprocal Resistance Formula is Applied
   b. R1 & R6 are in Series with R_{eq}
6. Determine Total Resistance: RT = R1 + R_{eq} + R6

Series-Parallel Circuit

R1 is in Series with the Parallel Branches R2–R3



R1
18 Ω
Node
A
E_t
60V
−
+
R2
20 Ω
R3
30 Ω
B
Node

SELECTED INSTRUCTIONAL ACTIVITIES

1. Review the selection and reading of the correct scales on the multimeter. (E 1.9.4)
2. Demonstrate proper hook-up procedure in a series-parallel circuit. (E 1.9.4)
3. Discuss safety practices used in making measurements in a live circuits. (E 1.9.4)
4. Demonstrate how Ohm's law applies to a series-parallel circuit. (E 1.9.2, E 1.9.5, and E 1.9.8)
5. Demonstrate series-parallel resistance addition formulas. (E 1.9.2, E 1.9.5, and E 1.9.8)
6. Demonstrate how a series-parallel circuit can be reduced to an equivalent series circuit containing only one resistor. (E 1.9.1 and E 1.9.2)
7. Have students verify experimentally the law for total resistance R_T of a series-parallel circuit and that the voltage across each leg in a parallel circuit is the same as the voltage across the parallel circuit. (E 1.9.4)
8. Explain the theory of operation of the Wheatstone Bridge. (E 1.9.6 and E 1.9.7)
9. Have students work several problems solving for branch current, total current, total resistance, total power and voltage drops in a series-parallel circuit. (E 1.9.8)
10. Explain how to design a series-parallel network that will meet specific requirement of current, and resistance. (E 1.9.5)
11. Explain how both negative and positive voltages are obtained using a single power source. (E 1.9.3)

SELECTED TOOLS AND MATERIALS

Multimeter and leads
Three selected resistors
Bread board
Hook-up wire
D. C. power supply (regulated variable)
Wire strippers
SPST switch
Galvanometer
Overhead projector

SELECTED AUDIOVISUAL MATERIALS

"Series-Parallel Circuit" (transparency)
"Steps to Simplify a Series-Parallel Circuit" (transparency)
"Series-Parallel Circuit and Equivalent Circuit" (transparency)
"Circuit Reduction" (transparency)
"Basic Electricity and Electronics: Direct Current" (filmstrip), Bergwall Productions

SELECTED REFERENCES

Basic Electronics, 5th Edition. Bernard Grob. (Chapter 5)

Introductory Circuit Analysis, 4th Edition. Robert L. Boylestad. (Chapter 6)

Basic Electricity: A Text-Lab Manual, 5th Edition. Paul B. Zbar. (Experiment 14)

DUTY AREA

1. DEMONSTRATING D.C. KNOWLEDGE

PROGRAM

TASK/COMPETENCY

1.10 Analyze loaded and unloaded resistive voltage divider circuits

COURSE

1.10

PERFORMANCE OBJECTIVE

P 1.10 Given a resistive voltage divider, analyze the effects of a load on the voltage divider by comparing the currents through and the voltage drops across each resistor, with and without a load; the results must match those obtained by the instructor.

SELECTED ENABLING OBJECTIVES

E 1.10.1 Use the proportional voltage method to calculate the voltage drop across each resistor in a series circuit containing three (3) resistors.

E 1.10.2 Use the conductance formula ($I = G/G_T I_T$) to calculate the branch currents in a current divider with three (3) branches.

E 1.10.3 Define the following:

A. Series voltage dividers,
B. Parallel current dividers, and
C. Bleeder current.

E 1.10.4 Design a loaded voltage divider circuit consisting of three (3) series resistors with three (3) different loads.

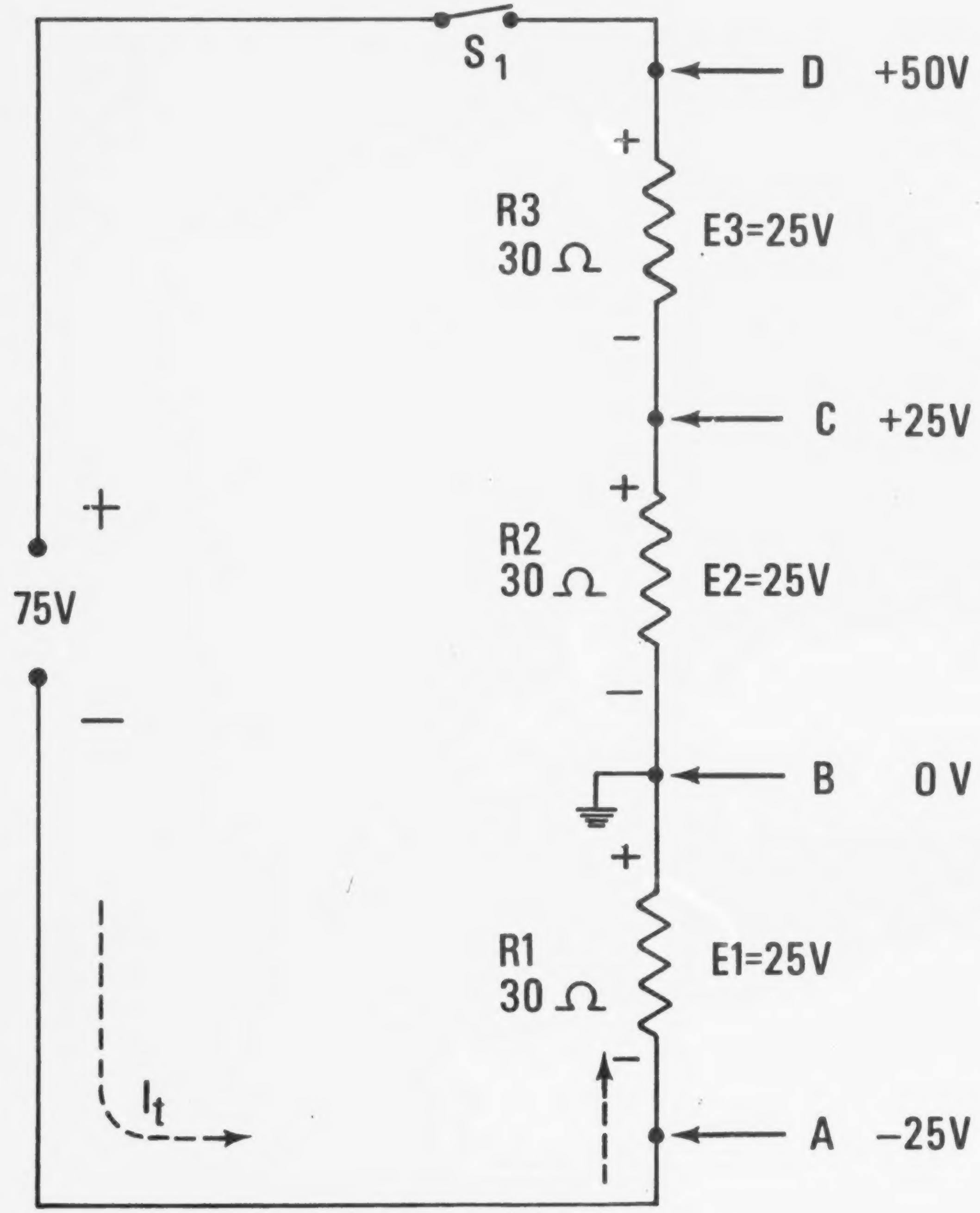
E 1.10.5 Confirm experimentally the general law for computing the voltage across each resistor in an unloaded fixed resistive voltage divider.

E 1.10.6 Construct the circuit designed in E 1.10.4 and confirm, by measurements, the design parameters.

CRITERION-REFERENCED MEASURE

C 1.10 Analyze the effects of a load on the voltage divider by comparing the currents through and the voltage drops across each resistor, with and without a load; the results must match those obtained by the instructor.

Voltage Divider


S1
D +50V
+
R3
30 Ω
E3=25V
−
C +25V
+
R2
30 Ω
E2=25V
−
+
75V
−
B 0 V
+
R1
30 Ω
E1=25V
−
It
A −25V

SELECTED INSTRUCTIONAL ACTIVITIES

1. Discuss series resistive voltage dividers and the proportional voltage methods for solving for the voltage drop across each resistor. (E 1.10.1 and E 1.10.3)

2. Discuss current dividers and explain why conductance is used instead of resistance to calculate branch current when the circuit has three (3) or more branches. (E 1.10.2 and E 1.10.3)

3. Discuss the effects of a load on the voltage drops across each resistor in a series voltage divider. (E 1.10.4)

4. Explain bleeder current and how it is used to design a loaded voltage divider. (E 1.10.3 and E 1.10.4)

5. Have students confirm experimentally the general law for computing the voltage across each resistor in an unloaded fixed resistive voltage divider. (E 1.10.5)

6. Have students construct the circuit, and confirm, by measurement, the design parameters of a loaded voltage divider circuit. (E 1.10.6)

SELECTED TOOLS AND MATERIALS

D. C. Power Supply (regulated variable)
Multimeter and leads
Milliammeter
Selected resistors
Hook-up wire
Bread boards
Wire strippers
SPST switch
Potentiometer

SELECTED AUDIOVISUAL MATERIALS

"Voltage Divider" (transparency)

SELECTED REFERENCES

Basic Electronics, 5th Edition. Bernard Grob. (Chapter 7)

Introductory Circuit Analysis, 4th Edition. Robert L. Boylestad. (Chapter 5)

Basic Electricity: A Text-Lab Manual, 5th Edition. Paul B. Zbar. (Experiment 10 and 18)

DUTY AREA

1. DEMONSTRATING D.C. KNOWLEDGE

PROGRAM

TASK/COMPETENCY

1.11 Analyze D.C. circuits using Kirchhoff's law

COURSE

1.11

PERFORMANCE OBJECTIVE

P 1.11 Given a schematic diagram of a D.C. series-parallel circuit that contains three (3) branches and two (2) generators, the values for each resistor and the generator voltages, use Kirchhoff's law to find the voltage drop across each resistor, the current flow, and its direction in each branch; all values must be within ±1% of instructor-calculated values.

SELECTED ENABLING OBJECTIVES

E 1.11.1 State Kirchhoff's current law in two (2) ways.

E 1.11.2 State Kirchhoff's voltage law in two (2) ways.

E 1.11.3 Describe the difference between a loop and a mesh.

E 1.11.4 Describe the difference between a branch current and a mesh current.

E 1.11.5 Define a principal node.

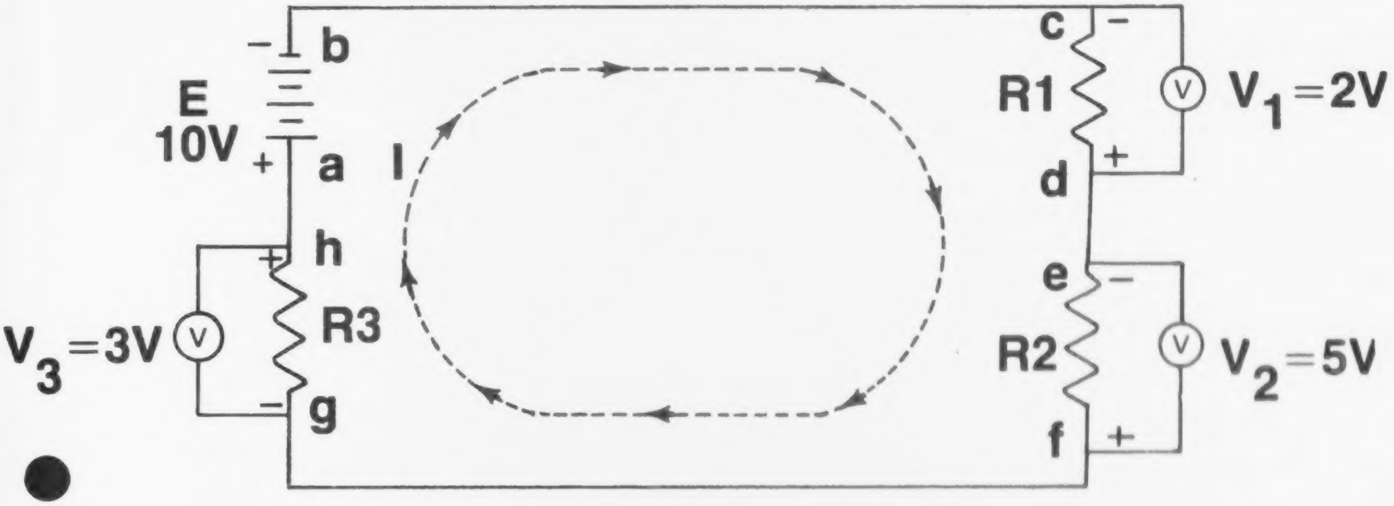
E 1.11.6 Define a node voltage.

E 1.11.7 Solve several circuit problems applying Kirchhoff's law.

CRITERION-REFERENCED MEASURE

C 1.11 Use Kirchhoff's law to find the voltage drop across each resistor, the current flow, and its direction in each branch; all values must be within ±1% of instructor calculated values.

Voltage Drops in a Resistive Circuit



b
E
10V
a
I
h
R3
$V_3 = 3V$
g
c
R1
$V_1 = 2V$
d
e
R2
$V_2 = 5V$
f

Applied Voltage (E) = 10V

Direction of Electron Flow: Negative (b) to Positive (a)

Application of Kirchhoff's Law of Voltage:

$$V_1 + V_2 + V_3 \text{ — } E1$$

$$2V + 5V + 3V = 10V$$

Kirchhoff's Law of Voltage

The algebraic sum of the voltages around a closed loop must equal the applied voltage.

SELECTED INSTRUCTIONAL ACTIVITIES

1. Discuss Kirchhoff's current law and demonstrate how it is used to analyze D.C. circuits. (E 1.11.1)
2. Discuss Kirchhoff's voltage law and demonstrate how it is used to analyze D.C. circuits. (E 1.11.2)
3. Demonstrate the writing of loop equations and how they may be used to analyze D.C. circuits. (E 1.11.3)
4. Review simultaneous equations with up to three (3) unknowns applying determinants. (E 1.11.7)
5. Demonstrate the writing of node equations and how they may be used to analyze D.C. circuits. (E 1.11.5 and E 1.11.6)
6. Demonstrate the writing of mesh equations and how they may be used to analyze D.C. circuits. (E 1.11.3 and E 1.11.4)
7. Assign students several problems in D. C. circuit analyses applying Kirchhoff's law; the problem should have both one (1) and two (2) generator circuits containing two (2) and three (3) branches. (E 1.11.7)

SELECTED TOOLS AND MATERIALS

Overhead projector

SELECTED AUDIOVISUAL MATERIALS

"Kirchhoff's Law of Voltage" (transparency)
"Voltage Drops in a Resistive Circuit" (transparency)

SELECTED REFERENCES

Basic Electronics, 5th Edition. Bernard Grob. (Chapter 9)

Introductory Circuit Analysis, 4th Edition. Robert L. Boylestad. (Chapter 5 and 7)

DUTY AREA

PROGRAM

1. DEMONSTRATING D.C. KNOWLEDGE

TASK/COMPETENCY

COURSE

1.12 Analyze D.C. circuits using the superposition theorem

1.12

PERFORMANCE OBJECTIVE

P 1.12 Given a schematic diagram of a D.C. resistive circuit that has two (2) voltage sources, the value of the voltage sources, and the value of the resistors, use the superposition theorem to calculate the value of the voltage across the load resistor; all calculated values must be within 1% of instructor-calculated values.

SELECTED ENABLING OBJECTIVES

E 1.12.1 State the superposition theorem.

E 1.12.2 Explain how voltage sources and current sources are disabled when applying the superposition theorem.

E 1.12.3 Solve several circuit problems using the superposition theorem.

CRITERION-REFERENCED MEASURE

C 1.12 Use the superposition theorem to calculate the value of the voltage across the load resistor; all calculated values must be within 1% of instructor calculated values.

SELECTED INSTRUCTIONAL ACTIVITIES

1. Explain the superposition theorem and explain some of its applications. (E 1.12.1)
2. Demonstrate the application of the superposition theorem by solving several circuit problems containing two (2) or more power sources. (E 1.12.2 and E 1.12.3)
3. Have the students solve several circuit problems applying the superposition theorem. (E 1.12.3)

SELECTED TOOLS AND MATERIALS

SELECTED AUDIOVISUAL MATERIALS

SELECTED REFERENCES

Basic Electronics, 5th Edition. Bernard Grob. (Chapter 10)

Introductory Circuit Analysis, 4th Edition. Robert L. Boylestad. (Chapter 8)

DUTY AREA

1. DEMONSTRATING D.C. KNOWLEDGE

PROGRAM

TASK/COMPETENCY

1.13 Use Thevenin's and Norton's thereoms

COURSE

1.13

PERFORMANCE OBJECTIVE

P 1.13 Given a resistive circuit that has two (2) voltage sources, the values for voltages, the values of the resistors, and the load resistance R_L, use Thevenin's theorem to calculate V_{TH} and R_{TH}, and use Norton's theorem to calculate I_N and R_N, and use Thevenin'Norton conversion formulas to convert between the two (2) equivalent forms of the circuit; all calculated values must be within 1% of instructor-calculated values.

SELECTED ENABLING OBJECTIVES

E 1.13.1 Calculate the Thenenin equivalent voltage and series resistance for a given circuit.

E 1.13.2 Calculate the Norton equivalent current source and parallel resistance for a given circuit.

E 1.13.3 Using the conversion formulas, convert between Norton's and Thevenin's equivalent circuits.

E 1.13.4 Calculate the current through the load resistor of an unbalanced bridge circuit using Thevenin's theorem.

E 1.13.5 Conduct an experiment to confirm the values V_{TH} and R_{Th} proposed by Thevenin's theorem in the solution of unbalanced bridge circuits.

E 1.13.6 Conduct an experiment to verify the values of I_N and R_N proposed by Norton's theorem in the solution of complex D.C. networks containing two voltage sources.

E 1.13.7 Explain why maximum power will be transferred to the load when $R_L=R_{TH}$.

CRITERION-REFERENCED MEASURE

C 1.13 Use Thevenin's theorem to calculate V_{TH} and R_{TH}, and use Norton's theorem to calculate I_N and R_N, and use Thevenin-Norton conversion formulas to convert between the two (2) equivalent forms of the circuit; all calculated values must be within 1% of instructor claculated values.

SELECTED INSTRUCTIONAL ACTIVITIES

1. Explain Thevenin's theorem and demonstrate the calculation of the equivalent Thevenin circuit. (E 1.13.1)
2. Explain Norton's theorem and demonstrate the calculation of the equivalent Norton circuit. (E 1.13.2)
3. Demonstrate the conversion between the equivalent Norton and Thevenin circuits. (E 1.13.3)
4. Explain the maximum power transfer theorem. (E 1.13.7)
5. Explain how to thevenize an unbalanced bridge circuit. (E 1.13.4)
6. Have students conduct experiments to confirm experimentally the values V_{Th} and R_{Th} proposed by Thevenin's theorem in the solution of unbalanced bridge circuits. (E 1.13.5)
7. Have the students verify experimentally the values I_N and R_N proposed by Norton's theorem in the solution of complex D. C. networks containing two voltage sources. (E 1.13.6)

SELECTED TOOLS AND MATERIALS

Power supply (two regulated voltaged-variable D. C. sources)
Digital VOM or EVM
Selected resistors
Three SPST switches
Milliammeter
Resistor decade box
Potentiometer 10,000 OHMS, 2 WATT

SELECTED AUDIOVISUAL MATERIALS

SELECTED REFERENCES

Basic Electronics, 5th Edition. Bernard Grob. (Chapter 10)

Introductory Circuit Analysis, 4th Edition. Robert L. Boylestad. (Chapters 7 and 8)

Basic Electricity: A Text-Lab Manual, 5th Edition. Paul B. Zbar. (Experiments 24 and 25)

DUTY AREA

1. DEMONSTRATING D.C. KNOWLEDGE

PROGRAM

TASK/COMPETENCY

1.14 Use Millman's theorem

COURSE

1.14

PERFORMANCE OBJECTIVE

P 1.14 Given a D.C. circuit containing two (2) voltage sources and three (3) parallel branches, the values of the voltage sources, and the values of the resistors, calculate the common voltage across the parallel branches; the calculated values must be within 1% of instructor calculated values.

SELECTED ENABLING OBJECTIVES

E 1.14.1 Define Millman's theorem.

E 1.14.2 Identify the type of circuit where Millman's theorem would apply.

E 1.14.3 Solve several circuit problems applying Millman's theorem.

CRITERION-REFERENCED MEASURE

C 1.14 Calculate the common voltage across the parallel branches; the calculated values must be within 1% of the instructor calculated values.

SELECTED INSTRUCTIONAL ACTIVITIES

1. Explain Millman's theorem and explain several of its applications. (E 1.14 1 and E 1.14.2)
2. Demonstrate the step by step process of applying Millman's theorem to a D.C. network containing three (3) voltage sources. (E 1.14.2 and E 1.14.3)
3. Have the students solve several circuit problems applying Millman's theorem. (E 1.14.3)

SELECTED TOOLS AND MATERIALS

SELECTED AUDIOVISUAL MATERIALS

SELECTED REFERENCES

Basic Electronics, 5th Edition. Bernard Grob. (Chapter 10)

Introductory Circuit Analysis, 4th Edition. Robert L. Boylestad. (Chapter 8)

DUTY AREA

1. DEMONSTRATING D.C. KNOWLEDGE

PROGRAM

TASK/COMPETENCY

1.15 Analyze bridge circuits

COURSE

1.15

PERFORMANCE OBJECTIVE

P 1.15 Given a schematic of a bridge circuit, the value of the voltage source, and the value of the resistors, calculate the voltage across the current through the balance arm of the bridge; all calculated values are to be within 1% of instructor-calculated values.

SELECTED ENABLING OBJECTIVES

E 1.15.1 Draw three (3) bridge networks using three (3) different forms.

E 1.15.2 Draw the schematic circuit for a tee or wye and a pi or delta network.

E 1.15.3 State the six (6) formulas needed to convert for wye to delta and delta to wye.

E 1.15.4 Convert a delta network to wye network showing all calculations.

E 1.15.5 Use the delta to wye conversion method to calculate the total resistance of a bridge circuit.

E 1.15.6 Calculate the voltage drop across the balance arm of a bridge network using mesh and nodal anlaysis.

E 1.15.7 Explain the difference between a balanced and an unbalanced bridge.

CRITERION-REFERENCED MEASURE

C 1.15 Calculate the voltage across and the current through the balance arm of the bridge; all calculated values are to be within 1% of instructor calculated values.

SELECTED INSTRUCTIONAL ACTIVITIES

1. Explain both balanced and unbalanced networks and their applications. (E 1.15.7)

2. Demonstrate the three (3) different forms a bridge network may have in a schematic circuit. (E 1.15.1)

3. Explain wye and delta networks and show examples of converting from one to the other. E 1.15.2 through E 1.15.4)

4. Demonstrate how a bridge network may be simplified by using delta to wye conversion. (E 1.15.5)

5. Review mesh and node analyses. (E 1.15.6)

SELECTED TOOLS AND MATERIALS

SELECTED AUDIOVISUAL MATERIALS

SELECTED REFERENCES

Basic Electronics, 5th Edition. Bernard Grob. (Chapter 10)

Introductory Circuit Analysis, 4th Edition. Robert L. Boylestad. (Chapter 7)

DUTY AREA

1. DEMONSTRATING D.C. KNOWLEDGE

PROGRAM

TASK/COMPETENCY

1.16 Identify types of batteries

COURSE

1.16

PERFORMANCE OBJECTIVE

P 1.16 Given several different types of batteries, identify which batteries are primary and which are secondary, give the output voltage of each cell, and tell which batteries can be recharged; all statements must be correct.

SELECTED ENABLING OBJECTIVES

E 1.16.1 List three (3) different primary cells and three (3) different secondary cells and give the output voltage of each.

E 1.16.2 Explain why the terminal voltage of a battery drops with an increase in the load current.

E 1.16.3 List the advantages of connecting cells in series.

E 1.16.4 List the advantages of connecting cells in parallel.

E 1.16.5 Explain a constant-current source and a constant-voltage source.

E 1.16.6 Draw a wiring diagram showing how cells are connected to double the voltage and current rating of a battery.

CRITERION-REFERENCED MEASURE

C 1.16 Identify which batteries are primary and which are secondary, give the ouput voltage of each cell, and tell which batteries can be recharged; all statements must be correct.

SELECTED INSTRUCTIONAL ACTIVITIES

1. Explain the different types of batteries and their advantages and disadvantages. (E 1.16.1)

2. Explain internal battery resistance and how it may be determined. (E 1.16.2)

3. Explain the advantages of connecting cells in parallel and in series. (E 1.16.3 and E 1.16.4)

4. Explain the terms:

   A. Constant current
   B. Constant voltage source. (E 1.16.5)

5. Demonstrate how cells may be connected in series to increase the voltage output and in parallel to increase the current output. (E 1.16.6)

SELECTED TOOLS AND MATERIALS

SELECTED AUDIOVISUAL MATERIALS

SELECTED REFERENCES

Basic Electronics, 5th Edition. Bernard Grob. (Chapter 12)

Introductory Circuit Analysis, 4th Edition. Robert L. Boylestad. (Chapter 2)

DUTY AREA

PROGRAM

1. DEMONSTRATING D.C. KNOWLEDGE

TASK/COMPETENCY

COURSE

1.17 Demonstrate the laws of magnetism

1.17

PERFORMANCE OBJECTIVE

P 1.17 Given a pair of similar magnets and materials, demonstrate magnetic attraction and repulsion, and state the laws of magnetism without error.

SELECTED ENABLING OBJECTIVES

E 1.17.1 Define:

A. Polarity,
B. North pole,
C. South pole,
D. Magnetic field,
E. Natural magnet
F. Artificial magnet, and
G. Ferrites.

E 1.17.2 Explain briefly the difference between a permanent magnet and an electromagnet.

E 1.17.3 Explain the behavior of a compass needle or a suspended magnet in the earth's magnetic field.

E 1.17.4 Explain the difference between flux and flux density B.

E 1.17.5 Determine experimentally the pattern of magnetic lines of force about:

A. A bar magnet,
B. Two (2) bar magnets with like poles near each other, and
C. Two (2) bar magnets with unlike poles near each other.

E 1.17.6 Name two (2) magnetic materials and three (3) nonmagnetic materials.

CRITERION-REFERENCED MEASURE

C 1.17 Demonstrate magentic attraction and repulsion and state the laws of magnetism without error.

SELECTED INSTRUCTIONAL ACTIVITIES

1. Define and explain key magnetism concepts and terms. (E 1.17.1 and E 1.17.2)
2. Discuss magnetic materials and their properties. (E 1.17.4 through E 1.17.6)
3. Explain the laws of magnetism. (E 1.17.3 through E 1.17.6)
4. Explain the different types of magnets. (E 1.17.1 and E 1.17.2)
5. Explain the classifications of magnetic materials. (E 1.17.6)
6. Discuss ferrites and their use. (E 1.17.1)
7. Have the students determine experimentally the pattern of magnetic lines force about:
   - A. A bar magnet
   - B. Two (2) bar magnets with like poles near each other
   - C. Two (2) bar magnets with unlike poles near each other. (E 1.17.5)

SELECTED TOOLS AND MATERIALS

Compass
Mounting stands
Sets of permanent magnets (including 2 bar magnets)
Wire and string for making saddles
Iron filings
Cardboard (8½"x11")
Overhead projector
Filmstrip projector
Audio cassette player

SELECTED AUDIOVISUAL MATERIALS

"Electricity and Magnetism". MP Inc. (filmstrip)
"Fundamentals of Alternating Current". Teaching Aids, Inc. (filmstrips/cassettes)
Transparency or chart showing details of structure for mounting magnets

SELECTED REFERENCES

Basic Electronics, 5th Edition. Bernard Grob. (Chapter 13)

Introductory Circuit Analysis, 4th Edition. Robert L. Boylestad. (Chapter 10)

Basic Electricity: A Text-Lab Manual, 5th Edition. Paul B. Zbar. (Experiment 26)

Electricity and Electronics. Howard Gerish and William E. Dugger. (Chapter 4)

Electricity: Principles and Applications. Richard Fowler. (Pages 110-129)

DUTY AREA

1. DEMONSTRATING D.C. KNOWLEDGE

PROGRAM

TASK/COMPETENCY

1.18 Explain magnetic hysteresis

COURSE

1.18

PERFORMANCE OBJECTIVE

P 1.18 Given a hysteresis loop for magnetic material, explain hysteresis losses in an iron core without error.

SELECTED ENABLING OBJECTIVES

E 1.18.1 Explain what is meant by ampere-turns.

E 1.18.2 Define field intensity, permeability, and saturation.

E 1.18.3 Explain why reluctance and permeability are considered opposite characteristics.

E 1.18.4 State Ohm's law for magnetic circuits.

E 1.18.5 Explain magentic dispoles and how they create energy loss when the external magnetizing force changes direction.

CRITERION-REFERENCED MEASURE

C 1.18 Explain hysteresis losses in an iron core without error.

SELECTED INSTRUCTIONAL ACTIVITIES

1. Explain magnetomotive force. (E 1.18.1)
2. Discuss field intensity, permeability, and saturation. (E 1.18.2 and E 1.18.3)
3. Explain hysteresis and hysteresis loss. (E 1.18.3 through E 1.18.5)
4. Discuss Ohm's law for magnetic circuits. (E 1.18.4)
5. Explain key concepts of the molecular theory of magnetism. (E 1.18.5)

SELECTED TOOLS AND MATERIALS

SELECTED AUDIOVISUAL MATERIALS

SELECTED REFERENCES

Basic Electronics, 5th Edition. Bernard Grob. (Chapter 14)

Introductory Circuit Analysis, 4th Edition. Robert L. Boylestad. (Chapter 10)

DUTY AREA

1. DEMONSTRATING D.C. KNOWLEDGE

PROGRAM

TASK/COMPETENCY

1.19 Determine the magnetic polarity of a solenoid

COURSE

1.19

PERFORMANCE OBJECTIVE

P 1.19 Given the diagram for a solenoid and the direction of electron flow, state the rules for determining the magnetic polarity, how the polarity can be reversed, and why there are no magnetic poles when the current through the solenoid is zero; all statements must be in accordance with Lenz' law.

SELECTED ENABLING OBJECTIVES

E 1.19.1 Explain two (2) factors about magnetic lines of force around current in a wire conductor.

E 1.19.2 Draw a diagram showing two (2) conductors connecting a battery to a load resistance through a closed switch and show the magnetic field of the current in the negative side of the line and in the positive side as well as describing where the two (2) fields aid and where they oppose.

E 1.19.3 State Lenz' law.

E 1.19.4 Explain why motor action between two (2) magnetic fields results in a motion toward the weaker field.

CRITERION-REFERENCED MEASURE

C 1.19 State the rules for determining the magnetic polarity, how the polarity can be reversed, and why there are no magnetic poles when the current through the solenoid is zero; all statements must be in accordance with Lenz' law.

SELECTED INSTRUCTIONAL ACTIVITIES

1. Explain how a magnetic field is created around an electric current. (E 1.19.1 and E 1.19.2)

2. Discuss how magnetic fields may either be aiding or cancelling. (E 1.19.1 and E 1.19.2)

3. Discuss Lenz' law. (E 1.19.3)

4. Explain the left-hand rule for determining magnetic polarity. (E 1.19.1 and E 1.19.2)

5. Explain motor action between two magnetic fields. (E 1.19.4)

SELECTED TOOLS AND MATERIALS

SELECTED AUDIOVISUAL MATERIALS

SELECTED REFERENCES

Basic Electronics, 5th Edition. Bernard Grob. (Chapter 15)

Introductory Circuit Analysis, 4th Edition. Robert L. Boylestad. (Chapter 10)

DUTY AREA

WORKING WITH AMPLIFIERS, OSCILLATORS, POWER SUPPLIES, AND ELECTRONIC DEVICES

TASK/COMPETENCY SEQUENCE

2.1 Explain the operation of a PN junction diode

2.2 Graph the voltampere characteristics of a zener diode

2.3 Design a seven-segment display circuit

2.4 Construct a half-wave rectifier circuit

2.5 Construct a full-wave rectifier circuit

2.6 Construct a voltage multiplier circuit

2.7 Explain the operation of junction transistors

2.8 Design a voltage-divider bias circuit

2.9 Design a common-emitter (CE) amplifier

2.10 Design and construct a common-collector (CC) amplifier

2.11 Calculate circuit characteristics using H parameters

2.12 Design a class A amplifier

2.13 Analyze class B push-pull emitter follower amplifiers

2.14 Analyze tuned class C amplifiers

2.15 Construct a voltage regulator circuit

2.16 Analyze the operation of a JFET circuit

2.17 Analyze a MOSFET circuit

2.18 Analyze the frequency response of an AC amplifier

2.19 Calculate decibel power gain and decibel voltage gain

2.20 Construct an IC regulated power supply

2.21 Design a Wien-bridge oscillator

2.22 Draw the I-V characteristic of an SCR

2.23 Analyze the operation of a triode vacuum tube amplifier

DUTY AREA

2. WORKING WITH AMPLIFIERS, OSCILLATORS, POWER SUPPLIES, AND ELECTRONIC DEVICES

PROGRAM

TASK/COMPETENCY

2.1 Explain the operation of a PN junction diode

COURSE

2.1

PERFORMANCE OBJECTIVE

P 2.1 Given the characteristic curves of a specified PN junction diode, explain the operation of the diode using the characteristic curve; biasing effects must be included in the explanation.

SELECTED ENABLING OBJECTIVES

E 2.1.1 List the two semiconducting materials used as the base material for junction diodes.

E 2.1.2 Draw the crystal pattern formed by silicon atoms.

E 2.1.3 State how electrons move from the valence band to the conduction band.

E 2.1.4 Define the terms: recombination, minority carrier, majority carrier, saturation current, bulk resistance, and breakdown voltage.

E 2.1.5 Explain the process of doping semiconductor material to produce N-type and P-type semiconductors.

E 2.1.6 State how the depletion layer is developed between a PN junction.

E 2.1.7 List the barrier potential in volts for silicon and germanium.

E 2.1.8 Draw a block diagram of a junction diode in forward bias.

E 2.1.9 State what occurs in a junction diode when reverse bias is applied.

E 2.1.10 Find Q, the operating point, of a specified junction diode by calculating and plotting a load line from given data.

E 2.1.11 Explain the effects of temperature on current flow (I_S) in a junction diode.

E 2.1.12 Graph a junction diode second approximation.

E 2.1.13 Perform an experiment to determine junction diode characteristics.

E 2.1.14 Graph the volt-amp curve of a PN junction diode.

CRITERION-REFERENCED MEASURE

C 2.1 Explain the operation of the PN junction diode using the characteristic curve; biasing effects must be included in the explanation.

SELECTED INSTRUCTIONAL ACTIVITIES

1. Discuss the types of semiconductor material used as base material for semiconductor devices. (E 2.1.1)
2. Explain the molecular structure of silicon and how the atoms combine to form a crystal. (E 2.1.2)
3. Discuss energy bands of a silicon atom and explain how electrons flow from the valence band to the conduction band. (E 2.1.3)
4. Explain the process of doping silicon and germanium to produce P-type and N-type materials. (E 2.1.5)
5. Explain why silicon is used more than germanium. (E 2.1.5)
6. Use a block diagram of a PN junction diode and explain the development of the depletion layer. (E 2.1.6)
7. Discuss the biasing of a diode, forward and reverse. (E 2.1.7. and E 2.1.8)
8. Explain what occurs within the depletion layer during forward and reverse biasing and the voltage needed to overcome the barrier potential in silicon and germanium. (E 2.1.7 and E 2.1.8)
9. Discuss:
   A. What majority and minority carriers are,
   B. Recombination,
   C. Saturation current (I_s) and temperature affects on (I_s), and
   D. Bulk resistance and breakdown volt. (E 2.1.4 and E 2.1.11)
10. Work some problems on the development of a load line and plot the points on a characteristic curve of a diode. (E 2.1.12)
11. Discuss and calculate first, second, and third approximations; demonstrate how to graph each. (E 1.1.12)
12. Have the students complete a lab on the characteristics of a PN junction diode. (E 2.1.13)
13. Discuss how to develop a graph for the volt amp characteristics of a PN junction diode. (E 2.1.14)

SELECTED TOOLS AND MATERIALS

D. C. power supply: variable regulated low-voltage high current
VOM
Curve tracer
Resistor: 250 ohm 2-W
1N4154 silicon diode or any small signal silicon diode
1N34A germanium diode or any small signal germanimum diode
SPST switch

SELECTED AUDIOVISUAL MATERIALS

Block diagram of a pn junction (teacher made)
Chart of schematic symbols for diodes (teacher made)

SELECTED REFERENCES

Electronic Principles. 3rd Edition. Albert P. Malvino. (Chapter 2).

Basic Electronics: A Text-Lab Manual. 5th Edition. Paul B. Zbar and Albert P. Malvino. (Experiment 1).

DUTY AREA

2. WORKING WITH AMPLIFIERS,
OSCILLATORS, POWER SUPPLIES,
AND ELECTRONIC DEVICES

PROGRAM

TASK/COMPETENCY

2.2 Graph the voltampere characteristics
of a zener diode

COURSE

2.2

PERFORMANCE OBJECTIVE

P 2.2 Given a diode circuit with a V_S=20V,R_S=1000 Ohms and a breakdown voltage of 6V, calculate I_Z and V_Z and graph the voltampere characteristics of a zener diode; the graph must show the Q point and calculated values must be within ±1% of instructor calculated values.

SELECTED ENABLING OBJECTIVES

E 2.2.1 Draw the schematic symbol of a zener diode.

E 2.2.2 List the three (3) regions in which a zener diode can operate.

E 2.2.3 Calculate the power disipation of a specified zener diode when V_Z and I_Z are given.

E 2.2.4 Explain why a zener diode is used as a voltage regulator.

E 2.2.5 Calculate a load line for a zener diode that has a breakdown voltage of 15V and V_S=20V, R_S=1.5K Ohms.

E 2.2.6 Calculate the second approximation of a zener diode that has a V_Z=10V, an R_S=1k Ohms, an R_Z of 10 Ohms, and the applied voltage (V_S) changes from 20-40V.

E 2.2.7 List the two (2) conditions a zener diode must meet to be a stiff zener regulator.

E 2.2.8 Explain the effect of temperature changes on zener voltage.

E 2.2.9 Perform an experiment to determine zener diode characteristics.

E 2.2.10 Calculate V_{TH} for a zener regulator with a load.

E 2.2.11 Explain why the maximum allowable series resistance in a zener regulator is referred to at the critical resistance.

CRITERION-REFERENCED MEASURE

C 2.2 Calculate I_Z and V_Z and graph the voltampere characteristics of a zener diode; the graph must show the Q point and all calculations must be within ±1% of instructor calculated values.

SELECTED INSTRUCTIONAL ACTIVITIES

1. Discuss the differences between the rectifier and zener diode and explain the operating regions of the zener diode. (E 2.1.2)
2. Display the schematic symbols for a rectifier diode and a zener diode and point out and explain their differences. (E 2.2.1)
3. Demonstrate how to calculate maximum power and rating of a zener diode and discuss why a zener diode is used as a voltage-regulator. (E 2.2.3 and E 2.2.4)
4. Demonstrate how to calculate a load line and identify the Q point. (E 2.2.5)
5. Discuss and demonstrate how to calculate a second approximation. (E 2.2.6)
6. Discuss the zener as a regulator and explain what conditions must exist if the zener diode is stiff. (E 2.2.7)
7. Discuss the effects of temperature changes and demonstrate how to calculate temperature coefficient. (E 2.2.8)
8. Have the students complete an experiment to determine the characteristics of a zener diode. (E 2.2.9)
9. Explain why it is necessary to use the Thevenin voltage driving the zener regulator with a load resistor and how to calculate V_{TH}. (E 2.2.10)
10. Explain critical resistance and its affects. (E 2.2.11)

SELECTED TOOLS AND MATERIALS

Variable regulated D.C. power source
Zener diode In3020 or any 1-W 10V zener
Resistor: 3500 Ohms, 0.5W

SELECTED AUDIOVISUAL MATERIALS

SELECTED REFERENCES

Electronic Principles. 3rd Edition. Albert P. Malvino. (Chapter 4).

Basic Electronics: A Text-Lab Manual. 5th Edition. Paul B. Zbar and Albert P. Malvino. (Experiment 3).

DUTY AREA

2. WORKING WITH AMPLIFIERS, OSCILLATORS, POWER SUPPLIES, AND ELECTRONIC DEVICES

PROGRAM

TASK/COMPETENCY

2.3 Design a seven-segment display circuit

COURSE

2.3

PERFORMANCE OBJECTIVE

P 2.3 Given circuit requirements, design a seven-segment display circuit controlled by on-off switches that have a maximum circuit current drain of 140mA.

SELECTED ENABLING OBJECTIVES

E 2.3.1 Draw the schematic symbol for a light emitting diode (L.E.D.)

E 2.3.2 State how recombination of electrons and holes causes the diode to emit light.

E 2.3.3 List three (3) L.E.D. characteristics that affect the voltage drop across an L.E.D.

E 2.3.4 Calculate L.E.D. current when V_s=12 Volts, V_{LED}=1.5V, and R_s=1000 Ohms.

E 2.3.5 State how to get constant brightness from an L.E.D.

E 2.3.6 Label the segments of a seven-segment drawing.

E 2.3.7 List the numbers and upper or lower case letters that a seven-segment L.E.D. can display.

E 2.3.8 Draw the schematic symbol for a photo diode.

E 2.3.9 State the advantage of a optocoupler.

E 2.3.10 Define the term "charge storage."

E 2.3.11 State the frequency at which "reverse recovery time" becomes important.

E 2.3.12 Explain how a "schottky barrier" is created.

E 2.3.13 Draw the equivalent circuit of a varactor.

E 2.3.14 State the differences between an abrupt and hyperabrupt junction.

E 2.3.15 List the primary uses of a back diode, tunnel diode, and varistors.

E 2.3.16 Perform an experiment on optoelectronic devices.

CRITERION-REFERENCED MEASURE

C 2.3 Design a seven-segment display circuit controlled by on-off switches that have a maximum circuit current drain of 140mA.

SELECTED INSTRUCTIONAL ACTIVITIES

1. Display the schematic symbols for light emitting and photo diodes. (E 2.3.1 and E 2.3.8)
2. Discuss how recombination causes a diode to emit light. (E 2.3.2)
3. Explain how the diodes current, color, and tolerance affects voltage drop. (E 2.3.3)
4. Demonstrate how to calculate L.E.D. current for a constant brightness level. (E 2.3.4 and E 2.3.5)
5. Display a seven-segment drawing and explain how the segments are labeled and give a list of numbers and letters that the unit can display. (E 2.3.6 and E 2.3.7)
6. Discuss optocouplers and explain their major advantage. (E 2.3.9)
7. Discuss:
   A. Charge storage,
   B. Reverse recovery time, and the
   C. Creation of a schottky barrier. (E 2.3.10 through E 2.3.12)
8. Discuss varactors and explain the abrupt and hyperabrupt junctions. (E 2.3.13 and E 2.3.14)
9. Discuss the use of back diodes, tunner diodes, and varistors. (E 2.3.15)
10. Have the students complete an experiment on optoelectronic devices. (E 2.3.16)

SELECTED TOOLS AND MATERIALS

2 power supplies, variable 0-15V
2 L.E.D.s TIL 221 and TIL222 or equivalent
2 1-WATT resistors: 270 Ohms
Seven-segment display: TIL 312 or equivalent
Optocoupler: 4N26 or equivalent
VOM (Analog or Digital)
Diode IN914 or equivalent

SELECTED AUDIOVISUAL MATERIALS

SELECTED REFERENCES

Electronic Principles. 3rd Edition. Albert P. Malvino. (Chapter 4).

Basic Electronics: A Text-Lab Manual. 5th Edition. Paul B. Zbar and Albert P. Malvino. (Experiment 4).

DUTY AREA

2. WORKING WITH AMPLIFIERS, OSCILLATORS, POWER SUPPLIES, AND ELECTRONIC DEVICES

TASK/COMPETENCY

2.4 Construct a half wave rectifier circuit

PROGRAM

COURSE

2.4

PERFORMANCE OBJECTIVE

P 2.4 Given the tools, materials, and schematic of a half-wave rectifier circuit, construct a half-wave rectifier circuit; the circuit's output wave form must be the positive alternation of the input signal.

SELECTED ENABLING OBJECTIVES

E 2.4.1 Define the terms:

- A. Root-mean-square (RMS),
- B. Average (AVG), and
- C. Peak (P) voltage.

E 2.4.2 Write the mathematical equations that represent the voltages and currents of an ideal transformer.

E 2.4.3 Calculate the effective values and ripple factor of a half-wave rectifier.

E 2.4.4 Perform an experiment to determine a half-wave rectifier circuit characteristics.

E 2.4.5 Measure input and output voltages of a half-wave rectifier.

E 2.4.6 Use an oscilloscope to display the output of a half-wave rectifier.

E 2.4.7 Explain peak inverse voltage (PIV) rating of a diode.

CRITERION-REFERENCED MEASURE

C 2.4 Construct a half-wave rectifier circuit; the circuit output waveform must be the positive alternation of the input signal.

SELECTED INSTRUCTIONAL ACTIVITIES

1. Review the sinosodal wave form and the various voltages associated with it. (E 2.4.1)
2. Review transformers and the equation for an "ideal transformer." (E 2.4.2)
3. Discuss half-wave rectifier circuits and explain the mathematical equations used to calculate effective values and ripple factor of the rectifier. (E 2.4.3)
4. Demonstrate how to construct a half-wave rectifier. (E 2.4.4)
5. Demonstrate how to connect an oscilloscope to a half-wave rectifier circuit and measure voltage. (E 2.4.5 and E 2.4.6)
6. Demonstrate how to change wave forms from the positive to the negative cycle. (E 2.4.5 and E 2.4.6)
7. Have the students complete an experiment on half-wave rectifiers. (E 2.4.4 and E 2.4.5)
8. Discuss peak inverse voltage (PIV) rating of a diode and its importance when selecting a diode for a half-wave rectifier circuit. (E 2.4.7)

SELECTED TOOLS AND MATERIALS

Transformer, 12.6 V.A.C. center-tapped or equivalent
4 silicon diodes: 1N4001 or equivalent
½-watt resistor: 1K Ohms
VOM (Analog or Digital)
Oscilloscope

SELECTED AUDIOVISUAL MATERIALS

SELECTED REFERENCES

Electronic Principles. 3rd Edition. Albert P. Malvino. (Chapter 3).

Basic Electronics: A Text-Lab Manual. 5th Edition. Paul B. Zbar and Albert P. Malvino. (Experiment 6).

DUTY AREA

2. WORKING WITH AMPLIFIERS, OSCILLATORS, POWER SUPPLIES, AND ELECTRONIC DEVICES

PROGRAM

TASK/COMPETENCY

2.5 Construct a full wave rectifier circuit

COURSE

2.5

PERFORMANCE OBJECTIVE

P 2.5 Given the tools, materials, and a transformer with a secondary voltage of 40 volts, design a full-wave rectifier with a capacitive input filter that will produce a wave form with a ripple of 10% or less.

SELECTED ENABLING OBJECTIVES

E 2.5.1 Draw schematics of a full-wave and bridge rectifier.

E 2.5.2 Explain how secondary voltage is divided between diodes in a full-wave rectifier.

E 2.5.3 Calculate the average output voltage of a full-wave rectifier with a specified peak voltage.

E 2.5.4 Explain how input frequency is doubled by a full-wave rectifier.

E 2.5.5 Calculate peak inverse voltage (PIV) of diodes in a full-wave rectifier at a specified secondary peak voltage.

E 2.5.6 Explain the advantage of a bridge rectifier's output over other full wave rectifiers.

E 2.5.7 Make a chart listing the characteristics of a half-wave, full-wave, and bridge rectifier.

E 2.5.8 Perform an experiment on full-wave and bridge rectifiers.

E 2.5.9 Calculate the ripple voltage of a rectifier from specified data using a capacitive input filter.

E 2.5.10 Explain how filtering effects rectifier output voltage.

CRITERION-REFERENCED MEASURE

C2.5 Design a full-wave rectifier with a capacitive input filter that will produce a waveform with a ripple of 10% or less.

SELECTED INSTRUCTIONAL ACTIVITIES

1. Discuss conventional and bridge full-wave rectifiers and explain how secondary voltage is distributed. (E 2.5.1, E 2.5.2, and E 2.5.6)
2. Explain how to manipulate the formulas to calculate average and peak voltages. (E 2.5.3)
3. Discuss how frequency is doubled in full-wave rectifier circuits. (E 2.5.4)
4. Demonstrate how to calculate peak inverse voltage (PIV) and discuss its relationship to peak secondary voltage. (E 2.5.5)
5. Demonstrate how to construct a conventional and bridge rectifier. (E 2.5.8)
6. Display a comparison chart of half-wave, full-wave, and bridge rectifiers. (E 2.5.7)
7. Have the students complete an experiment on full-wave rectifirers. (E 2.5.8)
8. Discuss capacitive input filtering used with rectifiers and explain how ripple voltage is calculated. (E 2.5.8 and E 2.5.9)
9. Discuss the affects of filtering on rectifier output voltage. (E 2.5.10)

SELECTED TOOLS AND MATERIALS

Oscilloscope, EVM
Resistors: 10,000 Ohm ½W, 5600 Ohm ½W, 100 Ohm 1W, 500 Ohm 5W
Two capacitors: 100uF 50-V
4 solid state diodes: 1N5625 or equivalent
5 SPST switches
Power transformers: 117V primary, 26 V center tapped secondary at 1-A (Triad F45X or equivalent)
Fused line cord

SELECTED AUDIOVISUAL MATERIALS

SELECTED REFERENCES

Electronic Principles. 3rd Edition. Albert P. Malvino. (Chapter 3).

Basic Electronics: A Text-Lab Manual. 5th Edition. Paul B. Zbar and Albert P. Malvino. (Experiment 6 and 10)

DUTY AREA

2. WORKING WITH AMPLIFIERS, OSCILLATORS, POWER SUPPLIES, AND ELECTRONIC DEVICES

PROGRAM

TASK/COMPETENCY

2.6 Construct a voltage multiplier circuit

COURSE

2.6

PERFORMANCE OBJECTIVE

P 2.6 Given the necessary components, construct a voltage multiplier circuit; the output voltage must be three (3) times greater than the input voltage.

SELECTED ENABLING OBJECTIVES

E 2.6.1 Draw schematics for a voltage doubler, tripler, and quadrupler.

E 2.6.2 State the purpose of voltage multiplier circuits.

E 2.6.3 Determine experimentally the affect on the output voltage when a voltage multiplier is increased from doubler to tripler.

E 2.6.4 State two (2) purposes for limiters.

E 2.6.5 Determine experimentally the affect biasing has on a limiter.

E 2.6.6 Explain how a clamper circuit modifies an input signal swing.

E 2.6.7 Determine experimentally how the difference between the R_L and C time constant and time period causes a modification of the input signal.

E 2.6.8 Explain why a capactively coupled source will not produce an output signal across an unbalanced load.

CRITERION-REFERENCED MEASURE

C 2.6 Construct a voltage multiplier circuit, the output voltage must be three (3) times greater than input voltage.

SELECTED INSTRUCTIONAL ACTIVITIES

1. Discuss voltage multiplier circuits and explain their purpose and display schematics of a doubler, tripler, and quadrupler circuit. (E 2.6.1 and E 2.6.2)

2. Demonstrate how to construct a voltage multiplier circuit. (E 2.6.3)

3. Have the students complete an experiment on voltage doublers and triplers. (E 2.6.3)

4. Discuss and explain the purpose of limiter, clamper, and coupler circuits. (E 2.6.4, E 2.6.6, and E 2.6.8)

5. Review how to calculate RMS, ripple frequency, peak-to-peak ripple, and capacitance. (E 2.6.2)

6. Have the students perform experiments on limiters and D.C. clamper circuits. (E 2.6.5 and E 2.6.7)

7. Review RC time constants. (E 2.6.7)

SELECTED TOOLS AND MATERIALS

Transformer: 12.6 VAC center tapped
2 diodes: 1N4001
2 diodes: 1N914
½ watt resistors: 1K Ohms, 470 Ohms, 10K Ohms, 100K Ohms, 47K Ohms
2 capacitors: 470 uF (25 volts)
2 capacitors: 1 uF (10 volts)
VOM
Oscilloscope
Audio generator
Power supply 0-15V

SELECTED AUDIOVISUAL MATERIALS

SELECTED REFERENCES

Electronic Principles. 3rd Edition. Albert P. Malvino. (Chapter 3).

Basic Electronics: A Text-Lab Manual. 5th Edition. Paul B. Zbar and Albert P. Malvino. (Experiments 5 and 9)

DUTY AREA

2. WORKING WITH AMPLIFIERS, OSCILLATORS, POWER SUPPLIES, AND ELECTRONIC DEVICES

PROGRAM

TASK/COMPETENCY

2.7 Explain the operation of junction transistors

COURSE

2.7

PERFORMANCE OBJECTIVE

P 2.7 Given a PNP and a NPN junction transistor, draw the schematic diagram for each and explain the operation of each by relating the following factor: I_C, I_B ,I_E, Beta, Alpha, and I_{CBO}; all explanations must be in accordance with standard acceptable theory and practice.

SELECTED ENABLING OBJECTIVES

E 2.7.1 State the difference between majority carrier and minority carriers in semiconductor materials.

E 2.7.2 Explain how a depletion region is produced across the junctions of an unbiased junction transistor and state the barrier potential for silicon and germanium.

E 2.7.3 Draw a block diagram of a PNP and an NPN transistor illustrating the proper biasing.

E 2.7.4 Draw and label the schematic symbol for a PNP and an NPN transistor.

E 2.7.5 State what is meant by D.C. alpha and write the equation used to calculate D.C. alpha.

E 2.7.6 Define D.C. beta and write the equation used to calculate D.C. beta.

E 2.7.7 State the relationship between D.C. alpha and D.C. beta.

E 2.7.8 Develop a load line on a given set of transistor collector curves and define the Q point, cutoff, and saturation.

E 2.7.9 Explain how a transistor may be used as a switch.

E 2.7.10 Define I_{CBO} and explain how temperature affects I_{CBO} in both germainum and silicon transistors.

E 2.7.11 Draw the schematic symbol for a phototransistor and explain how it operates.

E 2.7.12 Demonstrate how to test a transistor using an ohmmeter.

E 2.7.13 Perform an experiment on transistor biasing.

E 2.7.14 Draw the basing diagram for the transistor supplied and identify the emitter, base, and collector.

CRITERION-REFERENCED MEASURE

C 2.7 Draw the schematic diagram for a PNP and NPN junction transistor and explain the operation of each by relating the following factor: I_C,I_B, I_E, Beta, Alpha, and I_{CBO}: all explanations must be in accordance with standard acceptable theory and practice.

SELECTED INSTRUCTIONAL ACTIVITIES

1. Review semiconductor materials and explain the difference between majority and minority carriers. (E 2.7.1)
2. Discuss how the depletion region is produced across the junction of an unbiased transistor (relate this to diode) and give the potential for silicon and germanium. (E 2.7.2)
3. Explain leakage current (I_{CBO}) and how it is affected by temperature for both silicon and germanium. (E 2.7.10)
4. Demonstrate proper biasing by using a block diagram of a PNP and NPN transistor. (E 2.7.3)
5. Demonstrate the drawing of the schematic symbol for a PNP and an NPN transistor identifying each element. (E 2.7.4)
6. Explain D.C. alpha and how to use the equation to calculate D.C. alpha. (E 2.7.5)
7. Explain D.C. beta and how to use the equation to calculate D.C. beta. (E 2.7.6)
8. Explain the relationship between D.C. alpha and D.C. beta. (E 2.7.7)
9. Demonstrate the development of a D.C. load line on a set of transistor collector curves and define the Q point, cuttoff, and saturation. (E 2.7.8)
10. Explain the operation of a transistor switch. (E 2.7.9)
11. Discuss photo transistors and display its schematic symbol. (E 2.7.11)
12. Explain how a transistor may be treated as two (2) diodes and how to test the transistor with a schematic. (E 2.7.11)
13. Have the students conduct an experiment on transistor biasing. (E 2.7.13)
14. Demonstrate how to identify the element of a transistor from its base diagram. (E 2.7.14)

SELECTED TOOLS AND MATERIALS

Power supply: 1½ and 6V D.C. sources
2 multirange milliammeters or 20,000 Ohm/V
Resistors: 100 and 820 Ohm ½-W
Transistors: 2N6004 and 2N6005 or equivalent
2500 Ohm 2-W potentiometer
2 SPST switches

SELECTED AUDIOVISUAL MATERIALS

SELECTED REFERENCES

Electronic Principles. 3rd Edition. Albert P. Malvino. (Chapter 5).

Basic Electronics: A Text-Lab Manual. 5th Edition. Paul B. Zbar and Albert P. Malvino. (Experiment 11)

DUTY AREA

2. WORKING WITH AMPLIFIERS, OSCILLATORS, POWER SUPPLIES, AND ELECTRONIC DEVICES

PROGRAM

TASK/COMPETENCY

2.8 Design a voltage-divider bias circuit

COURSE

2.8

PERFORMANCE OBJECTIVE

P 2.8 Given an NPN transistor, the value of V_{CC}, I_C, and Beta D.C., design a voltage divider biased circuit; the circuit must have a stable Q point.

SELECTED ENABLING OBJECTIVES

E 2.8.1 Explain emitter-feedback bias and state why it is not used for linear operations.

E 2.8.2 Define cut-off and saturation.

E 2.8.3 Draw a circuit using collector-feedback bias and explain its operation.

E 2.8.4 Explain the advantage that collector-feedback bias has over emitter bias.

E 2.8.5 Explain why the Q point is set near the middle of the D.C. load line for linear operations.

E 2.8.6 Calculate the following voltages V_B, V_E, and V_C given the schematic drawing for a two stage RC coupled voltage-divider biased amplifier.

CRITERION-REFERENCED MEASURE

C 2.8 Design a voltage-divider biased circuit; the circuit must have a stable Q point.

SELECTED INSTRUCTIONAL ACTIVITIES

1. Discuss emitter-feedback bias and explain why it is not a practical circuit for linear operation. (E 2.8.1 and E 2.8.2)

2. Explain collector-feedback bias - - how to design the circuit using the D.C. load line and the effects of Beta D. C. (E 2.8.3)

3. Discuss the advantage collector-feedback bias has over emitter bias. (E 2.8.4)

4. Demonstrate, using a D.C. load line, why the Q point is set near the center for linear operations. (E 2.8.5)

5. Demonstrate how to calculate V_B, V_E, and V_C using a schematic diagram of a two stage RC coupled voltage-divider biased amplifier. (E 2.8.6)

SELECTED TOOLS AND MATERIALS

D.C. load line
Schematic diagram of a two stage RC coupled voltage-divider biased amplifier

SELECTED AUDIOVISUAL MATERIALS

SELECTED REFERENCES

Electronic Principles. 3rd Edition. Albert P. Malvino. (Chapter 6).

DUTY AREA

2. WORKING WITH AMPLIFIERS, OSCILLATORS, POWER SUPPLIES, AND ELECTRONIC DEVICES

PROGRAM

TASK/COMPETENCY

2.9 Design a common-emitter (CEO amplifier

COURSE

2.9

PERFORMANCE OBJECTIVE

P 2.9 Given the schematic drawing for a two-stage RC coupled common-emitter (CE) amplifier using swamping resistors, design the amplifier to meet the following specifications: V_{CC}=10V, R_s+1K Ohm, R_L=10K Ohm, Beta=125, 1V_{rms} output for 1mV_{rms} input; all design values must be within ±1% of instructor-calculated values.

SELECTED ENABLING OBJECTIVES

E 2.9.1 State the effects large and small signal inputs have on amplifier outputs.

E 2.9.2 Calculate the capacitor size needed for stiff coupling for a frequency between 100H_z to 200 H_z and a series resistance of 10K Ohms.

E 2.9.3 Draw the D.C. and A.C. equivalent circuits for a common-emitter (CE) amplifier.

E 2.9.4 Calculate the A.C. emitter resistance of a transistor.

E 2.9.5 Calculate A.C. Beta.

E 2.9.6 Graph an A.C. load line for a grounded-emitter amplifier.

E 2.9.7 Calculate the ouput voltage of a common-emitter amplifier that has an A.C. source voltage of 10 mV peak.

E 2.9.8 Conduct an experiment on common emitter (CE) amplifier biasing and gain.

E 2.9.9 Define what is meant by swamping.

E 2.9.10 State the affect cascaded stages have on amplifier output.

E 2.9.11 Conduct an experiment on troubleshooting CE amplifiers.

E 2.9.12 Conduct an experiment to measure the input and output impedance of a common emitter (CE) amplifier and determine the power and phase relationship.

CRITERION-REFERENCED MEASURE

C 2.9 Design an amplifier to meet the following specifications: V_{CC}=10K, R_s+1K Ohm, R_L-10K Ohm, Beta=125, 1V_{rms} output for 1MV_{rms} input; all design values must be within ±1% of instructor-calculated values.

SELECTED INSTRUCTIONAL ACTIVITIES

1. Discuss common-emitter amplifiers and explain how linearity is affected by increasing input signals. (E 2.9.1)
2. Explain how coupling and by-pass capacitors are used and their effect on CE amplifiers. (E 2.9.2)
3. Demonstrate how to calculate capacitor size for specified frequency ranges. (E 2.9.2)
4. Discuss the superposition theorem for amplifiers and demonstrate how to draw D.C. and A.C. equivalent circuits. (E 2.9.3)
5. Explain the Eber-Moll A.C. model and demonstrate how to calculate (r_e) A.C. emitter resistance. (E 2.9.4 and E 2.9.9)
6. Discuss the swamped amplifier and what swamping means. (E 2.9.4 and E 2.9.9)
7. Demonstrate how to construct a common-emitter and grounded-emitter amplifier and show how to take measurements, graphing A.C. load line, and calculating Beta. (E 2.9.5 through E 2.9.7)
8. Have the students perform an experiment on common-emitter biasing and gain. (E 2.9.8)
9. Discuss multi-stage amplifiers (cascading). (E 2.10.10)
10. Discuss the techniques used in troubleshooting CE amplifiers and assign an experiment on troubleshooting CE amplifiers to the students. (E 2.9.11)
11. Discuss the techniques used to measure input and output impedance, power and phase relationship. (E 2.9.12)

SELECTED TOOLS AND MATERIALS

Low voltage variable power supply
Oscilloscope, EVM
AF sine-wave generator
Resistors: ½ Watt, 470, 560, 1K, 4.7K 8.2K, and 18 K Ohms
Capacitors: 25 uF 50V, 100 uF 50 V
Semiconductors: 2N6004, 1N 4154 or equivalent
SPST switch, 500 Ohm 2-W potentiometer
Bread board
Hook-up wire
Needle nose pliers
Diagonal cutter

SELECTED AUDIOVISUAL MATERIALS

SELECTED REFERENCES

Electronic Principles. 3rd Edition. Albert P. Malvino. (Chapter 7).

Basic Electronics: A Text-Lab Manual. 5th Edition. Paul B. Zbar and Albert P. Malvino. (Experiment 15, 16, and 17)

DUTY AREA

2. WORKING WITH AMPLIFIERS, OSCILLATORS, POWER SUPPLIES, AND ELECTRONIC DEVICES

PROGRAM

TASK/COMPETENCY

2.10 Design and construct a common-collector (CC) amplifier

COURSE

PERFORMANCE OBJECTIVE

P 2.10 Given the specifications of V_{CC}=15V, I_c=2MA, B (Beta)=100, z_{in} z_{in}=10K Ohms, and z_{out}=112 Ohms, design and construct a common-collector amplifier; measurements of input and output impedance must be within ±10% of the specified values.

SELECTED ENABLING OBJECTIVES

E 2.10.1 State two additional names for the common collector amplifier and tell which one is most commonly used.

E 2.10.2 Write the formula used to calculate the voltage gain for an emitter follower and explain why the voltage gain is approximately equal to one.

E 2.10.3 Calculate the input and output impedance of an emitter follower.

E 2.10.4 Explain why the input and output voltage of an emitter-follower are in phase.

E 2.10.5 Derive a simple A.C. model for an emitter follower.

E 2.10.6 Calculate the output voltage for a specified two stage emitter follower.

E 2.10.7 State one example where an emitter-follower is most often used.

E 2.10.8 Explain why it is important to isolate a high impedance source from a low impedance load.

E 2.10.9 Conduct an experiment on a common-collector amplifier.

E 2.10.10 Explain why the Darlington amplifier is a popular transistor circuit.

E 2.10.11 List four (4) methods of coupling the output signal of one stage to the input of another stage and give the advantage of each.

E 2.10.12 Explain how an emitter follower can improve the performance of a zener regulator.

E 2.10.13 List the input and the output characteristics of CB, CE, and CC amplifiers.

CRITERION-REFERENCED MEASURE

C 2.10 Design and construct a common-collector amplifier; measurements of input and output impedance must be within ±10% of the specified values.

SELECTED INSTRUCTIONAL ACTIVITIES

1. Discuss the common-collector amplifier and demonstrate how to calculate Beta, voltage gain, input impedance and output impedance. (E 2.10.1, E 2.10.2, E 2.10.3, and E 2.10.7)
2. Explain why there is no phase inversion between the input and output of an emitter follower. (E 2.10.4)
3. Demonstrate how to derive a simple A.C. model for an emitter follower. (E 2.10.5)
4. Explain cascading of amplifiers and demonstrate how to calculate the output voltage. (E 2.10.6)
5. Discuss isolation-method used to isolate a high-impedance source from a low-impedance load and why it is important. (E 2.10.8)
6. Demonstrate how to measure the input impedance, the output impedance, power gain, and phase relationships of an emitter follower and have the students conduct an experiment to make the measurements. (E 2.10.9)
7. Explain the operations of the Darlington amplifier and give several examples of its use. (E 2.10.10)
8. Discuss the methods used to couple the output signal of one amplifier stage to the input of another and explain the advantage of each. (E 2.10.11)
9. Discuss the use of emitter follower to improve the performance of zener regulators. (E 2.10.12)
10. Discuss the common-base amplifier and explain the operational differences between the CB, CE, and CC amplifiers. (E 2.10.13)

SELECTED TOOLS AND MATERIALS

Power supply: variable regulated low-voltage D.C. source
Oscilloscope, EVM, sine-wave generator
Resistors: 3300, 12,000, and 470K Ohm ½-W
Capacitors: 25 uF 50V, 100 uF 50 V
Transistor: 2N2102 or equivalent
3 SPST switches, 500 Ohm 2-W potentiometer

SELECTED AUDIOVISUAL MATERIALS

SELECTED REFERENCES

Electronic Principles. 3rd Edition. Albert P. Malvino. (Chapter 8).

Basic Electronics: A Text-Lab Manual. 5th Edition. Paul B. Zbar and Albert P. Malvino. (Experiment 18)

DUTY AREA

2. WORKING WITH AMPLIFIERS, OSCILLATORS, POWER SUPPLIES, AND ELECTRONIC DEVICES

PROGRAM

TASK/COMPETENCY

2.11 Calculate circuit characteristics using H parameters

COURSE

2.11

PERFORMANCE OBJECTIVE

P 2.11 Given the necessary H parameters for a CE linear transistors circuit, calculate the voltage gain, the current gain, the output impedance and the input impedance; all calculated values must be within ±10% of instructor calculated values.

SELECTED ENABLING OBJECTIVES

E 2.11.1 Define H parameters.

E 2.11.2 List the four (4) parameters of the four (4) paramater system.

E 2.11.3 Explain the following parameters and their use:

A. Z parameters,
B. Y parameters, and
C. G parameters.

E 2.11.4 State the meaning of each of the following H parameters, the equation for each, and the condition under which it is measured:

A. H_{11},
B. H_{12},
C. H_{21}, and
D. H_{22}.

E 2.11.5 Calculate the voltage gain, input impedance, and output impedance of a given CE amplifier using H parameters.

E 2.11.6 Calculate the current gain, input impedance, and output impedance of a given CC amplifier using H parameters.

E 2.11.7 Calculate the current gain, voltage gain, input impedance, and output impedance of a given CB amplifier using H parameters.

E 2.11.8 Conduct an experiment on cascaded amplifiers.

CRITERION-REFERENCED MEASURE

C 2.11 Calculate the voltage gain, the current gain, and the output impedance of a CE linear transistor circuit; all calculated values must be within ± 10% of instructor calculated values.

SELECTED INSTRUCTIONAL ACTIVITIES

1. Discuss the four parameter system and explain how they are derived using Thevinin's and Norton's theorems. (E 2.11.2)
2. Define the h parameters and explain why they are used to analyze linear transistor circuits. (E 2.11.1)
3. Demonstrate, using a two-port network, how the Z, Y, and G parameters are derived and explain how they are used. (E 2.11.3)
4. Explain each of the h parameters, the equation for each, and the condition under which they are measured. (E 2.11.4)
5. Demonstrate how to calculate the voltage gain, input impedance, and output impedance of a CE amplifier using h parameters. (E 2.11.5)
6. Demonstrate how to calculate the current gain input impedance, and output impedance of a CC amplifier using h parameters. (E 2.11.6)
7. Demonstrate how to calculate the current gain, voltage gain, input impedance, and the output impedance of a CB amplifier using h parameters. (E 2.11.7)
8. Review cascaded amplifiers and have the students conduct an experiment to determine the linear operation of RC coupled amplifiers and the phase relationships. (E 2.12.8)

SELECTED TOOLS AND MATERIALS

Variable regulated low-voltage D.C. source
Oscilloscope, EVM, 0-25 mA D.C. milliammeter, AF generator
Resistors: 100, 470, 560, 1K, 8.2K, 10K, 18K and 33K Ohms, ½-W
Capacitors: 25 uF 50V, 100 uF 50 V (2 each)
Transistors: 2N6004; 2N2102, or equivalent
500 Ohm 2-W potentiometer
2 SPST switches

SELECTED AUDIOVISUAL MATERIALS

SELECTED REFERENCES

Electronic Principles. 3rd Edition. Albert P. Malvino. (Chapter 9).

Basic Electronics: A Text-Lab Manual. 5th Edition. Paul B. Zbar and Albert P. Malvino. (Experiment 20)

DUTY AREA

2. WORKING WITH AMPLIFIERS, OSCILLATORS, POWER SUPPLIES, AND ELECTRONIC DEVICES

PROGRAM

TASK/COMPETENCY

2.12 Design a class A amplifier

COURSE

2.12

PERFORMANCE OBJECTIVE

P 2.12 Given the schematic drawing of a class A amplifier and the necessary circuit parameters, develop the D.C. and A.C. load line and calculate Z_{in}, Z_{out}, A_v, A_p, P_L (max), I_s, P_s, and Beta; all calculations must be within ±1% of instructor-calculated values.

SELECTED ENABLING OBJECTIVES

E 2.12.1 Describe the difference between an A.C. load line and a D.C. load line.

E 2.12.2 Construct a D.C. load line and an A.C. load line for a common emitter (CE) class A amplifier circuit givent he schematic and required specifications.

E 2.12.3 Calculate the A.C. output compliance for the CE amplifier given in E 2.12.2.

E 2.12.4 Construct an A.C. load line for an emitter follower and calculate the A.C. output compliance.

E 2.12.5 Describe the difference in constructing an A.C. load line for a swamped amplifier than those used for a CE amplifier.

E 2.12.6 Explain how the A.C. output compliance can be increased for CE amplifiers.

E 2.12.7 Define class A operation of an amplifier.

E 2.12.8 Define the following terms as they apply to a class A common emitter amplifier:

A. Loaded voltage gain,
B. Current gain,
C. Power gain,
D. Loaded power gain, and
E. Maximum A.C. load power

E 2.12.9 Explain transistor power dissipation and how it relates to maximum transistor power dissipation.

E 2.12.10 State the formula used to calculate the D.C. current drain on a power supply assuming a stiff voltage divider in a class A amplifier.

E 2.12.11 Conduct an experiment to measure the characteristics of a class A amplifier.

CRITERION-REFERENCED MEASURE

C 2.13 Develop the D.C. and A.C. load lines and calculate Z_{in}, Z_{out}, A_v, A_p, P_L (max), I_s, P_s, and Beta; all calculations must be within ±1% of instructor-calculated values.

SELECTED INSTRUCTIONAL ACTIVITIES

1. Explain why every amplifier sees two loads; a D.C. and an A.C. load. (E 2.12.1)
2. Demonstrate how to develop a D.C. load line and an A.C. load line for a common emitter class A amplifier design and how they differ from each other. (E 2.12.1 and E 2.12.2)
3. Explain A.C. output compliance and demonstrate how it is calculated of CE amplifiers. (E 2.12.3)
4. Demonstrate how to construct an A.C. load line for an emitter follower and how to calculate the A.C. output compliance. (E 2.12.4)
5. Explain the difference between constructing an A.C. load line for a swamped amplifier than those used for a CE amplifier. (E 2.12.5)
6. Demonstrate how to increase the A.C. output compliance for a CE amplifier. (E 2.12.6)
7. Explain class A operations and demonstrate how each of the following may be calculated for a common emitter class A amplifier: (E 2.12.7 and E 2.12.8)
   A. Loaded voltage gain,
   B. Current gain,
   C. Power gain,
   D. Loaded power gain, and
   E. Maximum A.C. load power
8. Discuss transistor power dissipation and maximum transistor power dissipation and the precautions that must be used when calculating transistor power dissipation. (E 2.12.9)
9. Discuss current drain on a power supply and demonstrate how to calculate the D.C. current drain and the maximum power supplied to an amplifier. (E 2.12.10)
10. Discuss loud speakers and class A audio power amplifiers. (E 2.12.11)
11. Assign the students an experiment to measure the characteristics of a class A amplifier and discuss the safety precautions that must be observed during the experiment. (E 2.12.11)

SELECTED TOOLS AND MATERIALS

Variable regulated low-voltage D.C. source
Oscilloscope, EVM, 0-25 mA D.C. milliammeter, AF generator
Resistors: 100, 470, 1,000 Ohm, 4.7K, 5.1K, 18K, 33K Ohms, ½-W
Capacitors: 25 uF 50V, 100 uF 50 V (2 each), and 0.1 uF
Transistors: 2N6004; 2N2102, or equivalent
500 Ohm 2-W potentiometer
SPST switch
PM loudspeaker (3.2 Ohm)
Audio source
AF output transformer (Kelvin type 175-45 or equivalent)

SELECTED AUDIOVISUAL MATERIALS

SELECTED REFERENCES

Electronic Principles. 3rd Edition. Albert P. Malvino. (Chapter 10).

Basic Electronics: A Text-Lab Manual. 5th Edition. Paul B. Zbar and Albert P. Malvino. (Experiment 21)

DUTY AREA

2. WORKING WITH AMPLIFIERS, OSCILLATORS, POWER SUPPLIES, AND ELECTRONIC DEVICES

TASK/COMPETENCY

2.13 Analyze class B push-pull emitter follower amplifiers

PROGRAM

COURSE

2.13

PERFORMANCE OBJECTIVE

P 2.13 Given the schematic drawing for a class B push-pull emitter follower amplifier and the necessary circuit values, analyze the amplifier by calculating the AC output compliance, drawing the AC load line and the maximum load power; the AC load line and calculated values must be within ±1% of instructor calculated values.

SELECTED ENABLING OBJECTIVES

E 2.13.1 Define class B operation of a transistor amplifier.

E 2.13.2 List the advantage of class B operation over class A operation.

E 2.13.3 Draw the schematic diagram for a class B push-pull emitter follower and explain it's operation.

E 2.13.4 Define crossover distortion and explain how it may be eliminated.

E 2.13.5 Explain why a class B push-pull emitter follower amplifier produces less nonlinear distortion than a large signal class A amplifier.

E 2.13.6 Calculate the AC output compliance and the maximum load power for a class B push-pull emitter follower given the AC load line and the values of R_L.

E 2.13.7 Explain what is meant by transistors are complementary pairs.

E 2.13.8 Explain current mirror and how it compensates for temperature changes.

E 2.13.9 Explain how thermistors are used to compensate for temperature changes in a push-pull emitter follower.

E 2.13.10 Define Darlington pairs.

E 2.13.11 Explain derating factor D.

E 2.13.12 Explain how heat sinks are used to increase the power rating of a transistor.

E 2.13.13 Conduct an experiment on complimentary symmetry push-pull amplifiers.

CRITERION-REFERENCED MEASURE

C 2.13 Analyze the amplifier by calculating the AC output compliance, drawing the AC load line and the maximum load power; the AC load line and calculated values must be within ±1% of instructor calculated values.

SELECTED INSTRUCTIONAL ACTIVITIES

1. Explain class B operation, compare its operation to class A operation, and discuss the advantages of class B over class A operations. (E 2.13.1 and E 2.13.2)
2. Demonstrate how to draw a schematic diagram of a class B push-pull emitter follower and provide a detailed description of its operation. (E 2.13.3)
3. Explain crossover distortion and ways in which it may be eliminated. (E 2.13.4)
4. Discuss nonlinear distortion in large signal class A operations and class B operations. (E 2.13.5)
5. Demonstrate how to calculate the AC output compliance and the maximum load power for a class B push-pull emitter follower. (E 2.13.6)
6. Discuss transistor complementary pairs and their applications. (E 2.13.7)
7. Discuss the need for temperature compensation in transistor circuits and methods used to compensate for temperature changes. (E 2.13.8 and E 2.13.9)
8. Discuss Darlington pairs and their applications. (E 2.13.10)
9. Discuss transistor power rating and the durating factor D. (E 2.13.11)
10. Discuss heat sinks and their applications. (E 2.13.12)
11. Assign the students an experiment on complementary-symmetry push-pull amplifiers. (E 2.13.13)

SELECTED TOOLS AND MATERIALS

Two variable regulated low-voltage DC sources
Oscilloscope
EVM
AF sine-wave generator
Resistors: 5 Ohm, 100 Ohm, 470 Ohm, 1000 Ohm, 1200 Ohm 4.7 Ohm, 10K Ohm, ½W
Capacitors: 0.002uF, 25 uF 50-V, 100uF 50-V
Transistors: 2N2102 with heat sink, 2N4036 with heat sink, 2N6004 (or equivalents)
Two SPST switches
3.2 speaker
Potentiometer (500 Ohm 2-W)
Audio source

SELECTED AUDIOVISUAL MATERIALS

SELECTED REFERENCES

Electronic Principles. 3rd Edition. Albert P. Malvino. (Chapter 10).

Basic Electronics: A Text-Lab Manual. 5th Edition. Paul B. Zbar and Albert P. Malvino. (Experiment 23)

DUTY AREA

2. WORKING WITH AMPLIFIERS, OSCILLATORS, POWER SUPPLIES,

PROGRAM

TASK/COMPETENCY

2.14 Analyze tuned class C amplifiers

COURSE

2.14

PERFORMANCE OBJECTIVE

P 2.14 Given the schematic diagram for a tuned class C amplifier and the necessary values and waveforms at each point in the circuit, analyze the amplifier by explaining each wavform shown; the analysis must conform to the theory of operations.

SELECTED ENABLING OBJECTIVES

E 2.14.1 Define class C operations of an amplifier and explain why class C amplifiers always drive a resonant tank circuit.

E 2.14.2 Draw the frequency response curve for a parallel resonant tank circuit and state the formulas used to calculate f_r, bandwidth, Q_L, R_p, and Q of the circuit.

E 2.14.3 Explain the importance of T (the period of the input signal) and the time constant R_BC to DC clamping.

E 2.14.4 Define duty cycle and harmonics.

E 2.14.5 Explain how the load power, transistor dissipation, current drain, and stage efficiency of a class C amplifier differ from those a class A and and B amplifiers.

E 2.14.6 Explain how a tuned class C circuit can be used as a frequency multiplier.

E 2.14.7 Explain why a class D amplifier is very efficient.

E 2.14.8 Explain the meaning the dots used on circuit symbol of transformers.

CRITERION-REFERENCED MEASURE

C 2.14 Analyze the amplifier by explaining each waveform shown; the analysis must conform to the theory of operations.

SELECTED INSTRUCTIONAL ACTIVITIES

1. Explain class C operation of an amplifier and explain why it always drives a resonant tank circuit. (E 2.14.1)
2. Review series and parallel resonant circuits emphasizing the formula used to calculate the various circuit parameters and use the frequency response curve to demonstrate the effects resonants have on the circuit parameters. (E 2.14.2)
3. Discuss DC clamping, duty cycle, and haronics explaining each as they apply to class C amplifiers. (E 2.14.3 and E 2.14.4)
4. Discuss load power, transistor power, dissipation, current drain, and stage efficiency for class C amplifiers and explain how they differ from class A and class B amplifiers. (E 2.14.5)
5. Demonstrate, using a schematic diagram for a tuned class C amplifier, the voltages (DC) and the waveforms at each point in the circuit and explain how the circuit may be tuned to become a frequency multiplier. (E 2.14.6)
6. Demonstrate the operation of a class D amplifier using the schematic diagram, emphasizing signal tracing, input - output voltages and the meaning of the dots on transformer symbols. (E 2.14.7 and E 2.14.8)

SELECTED TOOLS AND MATERIALS

Schematic diagram for a tuned class C amplifier
Class D amplifier

SELECTED AUDIOVISUAL MATERIALS

SELECTED REFERENCES

Electronic Principles. 3rd Edition. Albert P. Malvino. (Chapter 11).

DUTY AREA

2. WORKING WITH AMPLIFIERS, OSCILLATORS, POWER SUPPLIES, AND ELECTRONIC DEVICES

PROGRAM

TASK/COMPETENCY

2.15 Construct a voltage regulator circuit

COURSE

2.15

PERFORMANCE OBJECTIVE

P 2.15 Given the equipment, schematics, and tools, construct a voltage regulator circuit and calculate its' percentage of regulation.

SELECTED ENABLING OBJECTIVES

E 2.15.1 State the purpose of a regulator circuit.

E 2.15.2 List the four (4) types of regulator circuits.

E 2.15.3 Draw the schematic diagram of a zener diode regulator circuit.

E 2.15.4 Construct a zener voltage regulator (zener regulator exp.)

E 2.15.5 State the purpose of current limiting in a voltage regulator circuit.

E 2.15.6 Measure the effects that line and load changes have on output voltage.

E 2.15.7 Calculate the percentage of regulation accomplished by the circuit.

CRITERION-REFERENCED MEASURE

C 2.15 Construct a voltage regulator circuit and calculate its percentage of regulation.

SELECTED INSTRUCTIONAL ACTIVITIES

1. Discuss voltage regulation circuits, the zener diode regulator, basic series regulator, shunted regulator, and series regulator with transistor feed back. (E 2.15.1 and E 2.15.2)

2. Display a schematic of a zener diode and discuss the principles of the diodes operation as a regulator. (E 2.15.3)

3. Have students draw the zener diode regulator schematic. (E 2.15.3)

4. Have students construct a transistor regulator and observe the affects of current limiting and the effects of line and load changes. (E 2.15.4-E 2.15.6)

5. Explain how to caculate percentage of regulation and work some sample problems to demonstrate formula manipulation; have students calculate percentage of regulation of their circuit. (E 2.15.7)

SELECTED TOOLS AND MATERIALS

Three zener diodes (1N753)
Center-tapped transformer (12.6V)
Four silicon diodes (IN 4001)
Resistors: ½-Watt, 150 Ohm, 470 Ohm, 4.7K Ohm, 47K Ohm
Two capacitors (470 uF, 25V)
VOM
Oscilloscope
Schematic of a zener diode voltage regulator circuit

SELECTED AUDIOVISUAL MATERIALS

SELECTED REFERENCES

Basic Electronic: A Text-Lab Manual. 5th Edition. Paul B. Zbar and Albert P. Malvino. (Experiment #36)

Electronic Principles. 3rd Edition. Albert P. Malvino. (Chapters 4, 8, and 19)

DUTY AREA

2. WORKING WITH AMPLIFIERS, OSCILLATORS, POWER SUPPLIES, AND ELECTRONIC DEVICES

PROGRAM

TASK/COMPETENCY

2.16 Analyze the operation of a JFET circuit

COURSE

2.16

PERFORMANCE OBJECTIVE

P 2.16 Given the schematic diagram for a CS amplifier and necessary circuit parameters, analyze the operation of the JFET circuit by calculating the value of the quiescent drain current, V_G, V_S, and V_D; all calculated values must agree within ±1% of instructor calculated values.

SELECTED ENABLING OBJECTIVES

E 2.16.1 State the meaning of the letters J F E T and draw the schematic symbol for an n-channel JFET and a p-channel JFET labeling each terminal.

E 2.16.2 Draw the block diagram for an n-channel JFET showing the proper biasing and explain how pinch off voltage is achieved.

E 2.16.3 Explain why self-bias is preferred to gate bias.

E 2.16.4 Identify the two (2) types of biasing methods that can be used to swamp out V_{GS} and draw a circuit diagram of each.

E 2.16.5 Define transconductance of a JFET and state how it affects the ability of gate voltage to control drain current.

E 2.16.6 Calculate the AC output voltage for a given CS amplifier with voltage divider bias.

E 2.16.7 Calculate the AC output voltage for a given source follower that drives a load resistor.

E 2.16.8 Explain how a JFET may be used as an analog switch.

E 2.16.9 Explain why a JFET makes an excellent buffer amplifier.

E 2.16.10 Conduct an experiment to determine the characteristic curves of a JFET.

CRITERION-REFERENCED MEASURE

C 2.16 Analyze the operation of the JFET circuit by calculating the values of the quiescent drain current, V_G, V_S, and V_D: all calculated values must agree within ±1% of instructor calculated values.

SELECTED INSTRUCTIONAL ACTIVITIES

1. Discuss n-channel and p-channel JFETS explaining the meaning of the letters JFET and the schematic symbol. (E 2.16.1)
2. Demonstrate, using the block diagram of a JFET, the proper biasing of a JFET, and explain how a JFET operates. (E 2.16.2)
3. Explain how pinehoff voltage is achieved and explain its meaning. (E 2.16.2)
4. Discuss the different types of biasing used to properly bias a JFET and explain the advantages and disadvantages of each. (E 2.16.3)
5. Explain the methods used to swamp out V_{GS} and use a circuit diagram of each method to demonstrate how swamping takes place. (E 2.16.4)
6. Discuss transconductance, its unit of measure, and its affects on the gate voltage ability to control drain current (use the transconductance curves to illustrate this affect). (E 2.16.5)
7. Demonstrate how the AC output voltage of a CS amplifier may be calculated and assign the students a problem to calculate the AC output voltage of a CS amplifier. (E 2.16.6)
8. Demonstrate how the AC output voltage of a source follower may be calculated and assign the students a problem to calculate the AC output voltage of a source follower. (E 2.16.7)
9. Discuss analog switches and explain how a JFET may be used as an analog switch. (E 2.16.8)
10. Discuss buffer amplifiers and explain why a JFET make an excellent buffer. (E 2.16.9)
11. Assign the student a laboratory experiment to determine characteristic curves of a JFET. (E 2.16.10)

SELECTED TOOLS AND MATERIALS

Two independent variable low-voltage DC sources
EVM (0-10 mA milliammeter)
2N5484 n-channel JFET (or equivalent)
Two SPST switches

SELECTED AUDIOVISUAL MATERIALS

SELECTED REFERENCES

Electronic Principles. 3rd Edition. Albert P. Malvino. (Chapter 12).

Basic Electronics: A Text-Lab Manual. 5th Edition. Paul B. Zbar and Albert P. Malvino. (Experiment #26)

DUTY AREA

2. WORKING WITH AMPLIFIERS,
OSCILLATORS, POWER SUPPLIES,
AND ELECTRONIC DEVICES

PROGRAM

TASK/COMPETENCY

2.17 Analyze a MOSFET circuit

COURSE

2.17

PERFORMANCE OBJECTIVE

P 2.17 Given the schematic diagram of a one-stage depletion-type MOSFET and the necessary circuit parameters, analyze the MOSFET circuit by calculating the voltage gain (when the input frequency is 10kHz), and the cutoff frequency; all calculations must be within ±1% of instructor calculated values.

SELECTED ENABLING OBJECTIVES

E 2.17.1 State the meaning of the letters M O S F E T and I G F E T.

E 2.17.2 Draw the block diagram for a depletion-type MOSFET, label each terminal, and explain why it is called a depletion type.

E 2.17.3 Draw the block diagram for a depletion-type MOSFET, label each terminal, bias to operate in this enhancement mode and explain how it is possible.

E 2.17.4 Explain why the square-law equation used for JFETs are also valid for depletiontype MOSFETS.

E 2.17.5 Draw the schematic symbol for the n-channel and the p-channel depletion-type MOSFETS and label each terminal.

E 2.17.6 State the types of biasing that may be used with depletion-type MOSFETS and explain why zero bias may be used with depletion-type MOSFETS and not with JFETS.

E 2.17.7 Explain why the input impedance of a MOSFET is much higher than that of the JFET and the junction transistor.

E 2.17.8 Calculate the unloaded voltage gain, input impedance, and output impedance at low frequencies of a cascade amplifier given the depletion-type MOSFET parameters and the circuit parameters.

E 2.17.9 Explain why enhancement-type MOSFETS are widely used in microprocessors and computer memories.

E 2.17.10 Define the term threshold voltage for enhancement-type MOSFETS.

E 2.17.11 Write the square-law equation for an enhancement-type MOSFET and explain why it is different from the equation for JFETS.

E 2.17.12 Draw the schematic symbol for a n-channel and a p-channel enhancement-type MOSFET and label each terminal.

E 2.17.13 Explain what precautions are necessary in handling MOSFETS and explain why they are necessary.

E 2.17.14 List the types of biasing methods used to bias an enhancement-type MOSFET and draw a schematic diagram of each method.

E 2.17.15 List several applications for enhancement-type MOSFETS.

E 2.17.16 Define CMOS and list several applications for CMOS.

E 2.17.17 Define VMOS and list its advantages over MOSFETS.

E 2.17.18 Conduct a laboratory experiment on a MOSFET common-source amplifier to determine drain characteristics, biasing arrangements, and voltage gain.

CRITERION-REFERENCED MEASURE

C 2.17 Analyze the MOSFET circuit by calculating the voltage gain (when the input frequency is 10kHz), and the cutoff frequency; all calculations must be within ±1% of instructor calculated values.

SELECTED INSTRUCTIONAL ACTIVITIES

1. Discuss n-channel and p-channel depletion-type MOSFET using a block diagram to explain its construction and operation. (E 2.17.1 and E 2.17.2)
2. Explain how a depletion-type MOSFET can be operated in the enhancement mode by changing the gate bias from negative to positive; use a block diagram of the device to illustrate how this is achieved. (E 2.17.3)
3. Explain the square-law equation for JFETS/MOSFETS using a transconductance curve, and illustrate the relation between drain current and gate source voltage for depletion-type MOSFETS. (E 2.17.4)
4. Demonstrate, using a schematic drawing, the different types of biasing methods used to bias depletion-type MOSFETS for both n-channel and p-channel devices and explain why zero biasing can be used with depletion-type MOSFETS and not with JFETS. (E 2.17.5 and E 2.17.6)
5. Explain how the structure of the gage of a MOSFET device makes the input impedance much larger than that of a JFET. (E 2.17.7)
6. Demonstrate how to calculate the input impedance, output impedance, and the unloaded voltage gain at low frequencies for a cascade amplifier using depletion. type MOSFETs and assign the students a problem to calculate the same parameters. (E 2.17.8)
7. Discuss the many applications of enhancement-type MOSFETS and explain why they are widely used in microprocessor and computer memories. (E 2.17.9)
8. Demonstrate the construction of an enhancement-type MOSFET using a block diagram and explain how the inversion layer is created emphasizing that the minimum V_{GS} that creates the n-type inversion layer is designated the threshold voltage. (E 2.17.10)
9. Discuss the square-law equation for an enhancement-type MOSFET, explain how the equation is used, and why it is different from the square-law equation used for JFETS. (E 2.17.11)
10. Demonstrate how to draw and label the schematic symbol for an enhancement-type MOSFET and explain how it differs from the JFET and the depletion-type MOSFET. (E 2.17.12)
11. Demonstrate, using several different MOSFETS, how they are packaged and the proper procedure for handling them. (E 2.17.13)
12. Demonstrate and explain the different types of biasing methods to bias an enhancement-type MOSFET, using a schematic diagram to illustrate each method and explain the application of each. (E 2.17.14 and E 2.17.15)
13. Explain how CMOS are constructed using p-channel and n-channel MOSFETS and discuss the application of CMOS. (E 2.17.16)
14. Demonstrate the structure of VMOS and discuss its advantages over MOSFETS. (E 2.17.17)
15. Assign the students laboratory experiments on a MOSFET common-source amplifier to determine drain characteristics, biasing arrangements, and the voltage gain. (E 2.17.18)

SELECTED TOOLS AND MATERIALS

Two independent variable regulated low-voltage DC sources
EVM (0-10 mA milliammeter (or equivalent)
VOM
Resistors: 1K Ohm, 10K Ohm, 2.2 M Ohm ½-W
Capacitors: 0.047 uF, 100 uF 50V
3N187 MOSFET (or equivalent)
Two SPST switches

SELECTED REFERENCES

Electronic Principles. 3rd Edition. Albert P. Malvino. (Chapter 13).

Basic Electronics: A Text-Lab Manual. 5th Edition. Paul B. Zbar and Albert P. Malvino. (Experiment #27)

DUTY AREA

2. WORKING WITH AMPLIFIERS,
OSCILLATORS, POWER SUPPLIES,
AND ELECTRONIC DEVICES

PROGRAM

TASK/COMPETENCY

2.18 Analyze the frequency response
of an AC amplifier

COURSE

2.18

PERFORMANCE OBJECTIVE

P 2.18 Given a circuit diagram of a common emitter RC coupled amplifier and the necessary circuit parameters, analyze the frequency response of the amplifier by calculating the cut-off frequencies; all calculations must be within ±1% of instructor calculated values.

SELECTED ENABLING OBJECTIVES

E 2.18.1 Define a lead network.

E 2.18.2 Explain the relationship between cut-off frequency and the half-power point of a lead network.

E 2.18.3 Calculate the cufoff frequencies of the input and output lead networks of a common emitter RC coupled amplifier given all the necessary circuit paramaters.

E 2.18.4 Explain why the higher cut-off frequency is called the dominant lead cut-off frequency whenever you have two or more lead networks.

E 2.18.5 Define a lag network.

E 2.18.6 Explain how an emitter bypass capacitor affects the frequency response of an RC coupled common emitter amplifier.

E 2.18.7 State Miller's theorem, the advantage of Miller's theorem and its most important application.

E 2.18.8 Calculate the cut-off frequencies of the gate and drain lag network for a JFET common source amplifier, given all the necessary circuit parameters.

E 2.18.9 Define current-gain-bandwidth product.

E 2.18.10 Perform an experiment to measure the frequency response of an audio amplifier.

E 2.18.11 Calculate the cutoff frequencies of a CE amplifier given the necessary circuit parameters and a data sheet for the transistor.

CRITERION-REFERENCED MEASURE

C 2.18 Analyze the frequency response of the amplifier by calculating the cut-off frequencies; all calculations must be within ±1% of instructor calculated values.

SELECTED INSTRUCTIONAL ACTIVITIES

1. Discuss the frequency effects of an AC amplifier explaining the term lead network and how x_c varies with frequency. (E 2.18.1)
2. Demonstrate, using a frequency response curve, the relationship between cut-off frequency and the half-power point for a lead network. (E 2.18.2)
3. Demonstrate how to calculate the frequency response of the input and output lead network of a CE RC coupled amplifier and assign a similar problem to the students. (E 2.18.3)
4. Demonstrate, using a frequency response curve, why the first break in amplifier response is called the dominant lead cut-off frequency. (E 2.18.4)
5. Discuss the difference between a lead network and a lag network use equivalent networks to demonstrate the difference. (E 2.18.5)
6. Discuss the emitter bypass capacitor and how it affects the frequency of an AC amplifier. (E 2.18.6)
7. Explain Miller's theorem and use the equivalent circuit to show the feedback capacitance and how the Miller input and output capacitance may be calculated. (E 2.18.7)
8. Demonstrate how to calculate the cut-off frequencies of the gate and drain lag network of a JFET common source amplifier and assign the students a similar problem. (E 2.18.8)
9. Explain current-gain-bandwidth product and demonstrate how it may be used to calculate C_e. (E 2.18.9)
10. Demonstrate how to calculate the cut-off frequencies of a CE amplifier and assign the student a similar problem. (E 2.18.11)
11. Assign the students a laboratory experiment to measure the frequency response of an audio amplifier. (E 2.18.10)

SELECTED TOOLS AND MATERIALS

Variable regulated low-voltage DC source
Oscilloscope
AF sine-wave generator
EVM
Resistors: 5, 100, 150, 330, 560, 1, 4.7, 5.1, 8.2, 10, 18, 33K, Ohm, ½-W
Capacitors: 25 uF, 50-V, 100 uF, 50V, 0.0047 uF, 0.047 uF
Transistors: 2N2102, 2N6004 (or equivalent)
500 Ohm, 2-W potentionmeter
SPST switch
Output transformer
Kelvin 175-45 (or equivalent)

SELECTED AUDIOVISUAL MATERIALS

SELECTED REFERENCES

Electronic Principles. 3rd Edition. Albert P. Malvino. (Chapter 14).

Basic Electronics: A Text-Lab Manual. 5th Edition. Paul B. Zbar and Albert P. Malvino. (Experiment #24)

DUTY AREA

2. WORKING WITH AMPLIFIERS, OSCILLATORS, POWER SUPPLIES, AND ELECTRONIC DEVICES

PROGRAM

TASK/COMPETENCY

2.19 Calculate decibel power gain and decibel voltage gain

COURSE

2.19

PERFORMANCE OBJECTIVE

P 2.19 Given a cascaded amplifier and the input and output power and voltage specifications, calculate the db power gain and the db voltage gain; all calculations must be within ±1% of instructor calculated values.

SELECTED ENABLING OBJECTIVES

E 2.19.1 Define db.

E 2.19.2 Explain how to calculate the power gain of an amplifier; use the power gain equation to prove your theory and state the unit of measure for power gain.

E 2.19.3 Describe how the db power changes as the power gain increases by a factor of 2 and 10.

E 2.19.4 Explain how a loss in power gain (attenuation) is expressed in db.

E 2.19.5 Explain why the total db power gain is equal to the sum of the individual db powers and also equal to the product of the individual power gain of a cascaded amplifier.

E 2.19.6 Explain how voltage gain can be converted to db power gain.

E 2.19.7 Develop a table that will show the relationship between db power gain and voltage gain.

E 2.19.8 Explain the conditions that are required before an impedance match can exist.

E 2.19.9 Explain dbm, its meaning, its advantage and where it is used.

E 2.19.10 Solve several problems using db and dbm as assigned by the instructor.

CRITERION-REFERENCED MEASURE

C 2.19 Calculate the db power gain and the db voltage gain; all calculations must be within ±1% of instructor calculated values.

SELECTED INSTRUCTIONAL ACTIVITIES

1. Review logarithms and explain the term decibel. (E 2.19.10)
2. Demonstrate how to calculate the power gain of an amplifier and explain its unit of measure. (E 2.19.2)
3. Demonstrate how to calculate the db power gain of an amplifier and explain how the db power changes as the power gain increases by a factor of 2 and 10. (E 2.19.3)
4. Discuss negative power gain and demonstrate how it may be calculated. (E 2.19.4)
5. Demonstrate how to calculate the power gain of cascaded amplifier stages using both the power gain equation and the db power gain equation. (E 2.19.5)
6. Demonstrate how to use the decibel voltage gain equation and explain the relation of power and voltage gain and have the students develop a table showing the relations between voltage gain and db power gain. (E 2.19.6 and E 2.19.7)
7. Discuss the importance of impedance matching and explain the conditions that are required before an impedance match can exist. (E 2.19.8)
8. Discuss dbm, its meaning, its advantage and where it is used. (E 2.19.9)
9. Assign the student several problems to calculate db and dbm. (E 2.19.10)

SELECTED TOOLS AND MATERIALS

SELECTED AUDIOVISUAL MATERIALS

SELECTED REFERENCES

Basic Electronic Principles. 3rd Edition. Albert P. Malvino. (Chapter 14)

DUTY AREA

2. WORKING WITH AMPLIFIERS, OSCILLATORS, POWER SUPPLIES, AND ELECTRONIC DEVICES

PROGRAM

TASK/COMPETENCY

2.20 Construct an IC regulated power supply

COURSE

2.20

PERFORMANCE OBJECTIVE

P 2.20 Given the schematic diagram, a three-terminal regulator and the necessary equipment construct a regulated power supply and measure the output load regulation (LR), source regulation (SR), and ripple rejection (RR); all measured values must be within ±10% of manufacturer's specifications.

SELECTED ENABLING OBJECTIVES

E 2.20.1 Explain why zener diodes with a zener voltage near 6V are used in voltage-feedback regulators.

E 2.20.2 Draw the schematic diagram for a series regulator that uses a Darlington pair for the pass transistor.

E 2.20.3 Explain why foldback limiting is preferred to simple current limiting in series regulators.

E 2.20.4 Define load regulation (LR) and write the equation used to calculate the percentage of load regulation.

E 2.20.5 Define source regulation.

E 2.20.6 Define ripple rejection and state its unit of measure.

E 2.20.7 Explain why the three-terminal IC regulators are preferred over descrete component regulators.

E 2.20.8 Draw the functional block diagram of a typical three-terminal IC voltage regulator; label each block and the three terminals.

E 2.20.9 Conduct a laboratory experiment using three-terminal IC regulators as an adjustable IC regulator and a current regulator.

E 2.20.10 List the advantages that a switching regulator has over a series regulator.

E 2.20.11 Explain why a diode must be connected between the emitter of the switching transistor and ground in a switching regulator.

CRITERION-REFERENCED MEASURE

C 2.20 Construct a regulated power supply and measure the output load regulation (LR), source regulation (SR), and ripple reflection (RR); all measured values must be within ±10% of manufacturer's specifications.

SELECTED INSTRUCTIONAL ACTIVITIES

1. Review zener diodes and explain the relationships between zener voltage of a diode and its temperature coefficient. (E 2.20.1)
2. Discuss series regulators that use a single pass transistor and Darlington pair pass transistors, and explain the operation of each using the schematic drawing. (E 2.20.2)
3. Explain why foldback limiting is preferred to simple current limiting in series regulators; use a schematic drawing of each to demonstrate the preferences. (E 2.20.3)
4. Discuss load regulation (LR) and work several problems to demonstrate how LR's percentage is calculated. (E 2.20.4)
5. Explain source regulation and demonstrate how it may be calculated. (E 2.20.5)
6. Explain ripple rejection and its unit of measure to the decibel. (E 2.20.6)
7. Discuss three-terminal IC regulators, explain why they are preferred over discrete component regulators, and use a functional block diagram to explain the operation. (E 2.20.7 and E 2.20.8)
8. Assign the students a laboratory experiment using three-terminal IC regulators to become familiar with fixed IC regulator, adjustable IC regulators and testing a current regulator. (E 2.20.9)
9. Demonstrate, using a schematic diagram of a switching regulator, the advantage a switching regulator has over a series regulator and explain why a diode must be connected from the emitter of the switching transistor to ground. (E 2.20.10 and E 2.20.11)

SELECTED TOOLS AND MATERIALS

Variable 1-25V DC source
Oscilloscope
Resistors: 47, 100, 150, 180 Ohm, ½-W
Capacitor (1uF)
VOM (DVM preferred)
IC regulator (LM 340-8)

SELECTED AUDIOVISUAL MATERIALS

SELECTED REFERENCES

Basic Electronic Principles. 3rd Edition. Albert P. Malvino. (Chapter 19)

Basic Electronics: A Text-Lab Manual. 5th Edition. Paul B. Zbar and Albert P. Malvino. (Experiment #37)

DUTY AREA

2. WORKING WITH AMPLIFIERS,
OSCILLATORS, POWER SUPPLIES,
AND ELECTRONIC DEVICES

PROGRAM

TASK/COMPETENCY

2.21 Design a Wien-bridge oscillator

COURSE

2.21

PERFORMANCE OBJECTIVE

P 2.21 Given the schematic diagram of a Wien-bridge oscillator and the specifications that it has three (3) decade frequency ranges of 10 Hz to 20 KHz with an output voltage of 5 Vrms, design the oscillator to meet the given specifications.

SELECTED ENABLING OBJECTIVES

E 2.21.1 Explain the basic requirements of a sinusoidal oscillator.
E 2.21.2 Explain how an oscillator gets its starting voltage.
E 2.21.3 Draw the feedback circuit used in a Wien-bridge oscillator, state its normal rangel of operating frequencies, and identify the feedback network.
E 2.21.4 State the formula used to calculate the resonant frequency of the Wien-bridge oscillator and state the phase shift of the lead-lag network at resonant.
E 2.21.5 Draw the schematic diagram of a Wien-bridge oscillator that uses a JFET as a voltage variable resistance to limit the output amplitude.
E 2.21.6 Calculate the minimum and maximum frequencies for a given Wien-bridge oscillator.
E 2.21.7 List two (2) RC oscillators other than the Wien-bridge.
E 2.21.8 List four (4) types of LC oscillators.
E 2.21.9 Explain the main reason why a Colpitts oscillator is preferred over a Wien-bridge oscillator at frequencies above one MHz.
E 2.21.10 Draw the schematic diagram for a Colpitts oscillator using a CE amplifier.
E 2.21.11 State the easiest way to recognize a Colpitts oscillator from a schematic diagram.
E 2.21.12 Draw the schematic diagram for each of the following oscillators:
A. Armstrong,
B. Hartley,
D. Clapp, and
E. Crystal.
E 2.21.13 State the formula used to calculate the resonant frequency of a Colpitts oscillator.
E 2.21.14 Define motorboating and state the most likely cause for motorboating.
E 2.21.15 Define parasitic oscillations and state the most like cause for them.
E 2.21.16 Conduct a laboratory experiment to build and test Wien-bridge oscillators.

CRITERION-REFERENCED MEASURE

C 2.20 Design an oscillator according to given specifications.

SELECTED INSTRUCTIONAL ACTIVITIES

1. Discuss the basic theory of sinusoidal oscillators; include in the discussion the importance of loop gain, phase relations, and the starting voltage. (E 2.21.1 and E 2.21.2)
2. Explain the theory of operations of a Wien-bridge oscillator; use a schematic drawing of the oscillator pointing out how the lead-lag network determines the resonant frequency and provide a brief explanation of op-amps. (E 2.21.3)
3. Discuss the formula used to calculate the resonant frequency of a Wien-bridge oscillator and explain the conditions under which the formula may be used. (E 2.21.4)
4. Demonstrate, using a schematic diagram, how a JFET may be used to limit the output amplitude of a Wien-bridge oscillator. (E 2.21.5)
5. Demonstrate how to calculate the minimum and maximum frequencies of a Wien-bridge oscillator and assign the students several problems to solve. (E 2.21.6)
6. Discuss twin-T and phase-shift oscillators and given examples of their use. (E 2.21.7)
7. Discuss the different types of LC oscillators and given examples of each. (E 2.21.8)
8. Explain, using a schematic diagram, the theory of operation of a Colpitts oscillator and why it is preferred over the Wien-bridge oscillator at frequencies above 1MHz. (E 2.21.9 and E 2.21.10)
9. Explain how a Colpitts oscillator can easily be identified. (E 2.21.11)
10. Demonstrate how to draw the schematic diagram of a Armstrong, Hartley, Clapp, and Crystal oscillator. (E 2.21.13)
11. Demonstrate how to calculate the resonant frequency of a Colpitts oscillator. (E 2.21.13)
12. Discuss motorboating and explain the most likely cause and how it may be eliminated. (E 2.21.14)
13. Discuss parasitic oscillations and explain the most likely cause and how it may be eliminated. (E 2.21.15)
14. Demonstrate how to construct and test a Wien-bridge Oscillator and have the students complete one. (E 2.21.6)

SELECTED TOOLS AND MATERIALS

Two 15V DC power sources
Oscilloscope
Resistors: 100, 270, 1K Ohm, 10K Ohm, ½W
Four 0.1 uF capacitors
Op Amp (741C)
Potentiometer (1K Ohm)
Electronic converter

SELECTED AUDIOVISUAL MATERIALS

SELECTED REFERENCES

Basic Electronic Principles. 3rd Edition. Albert P. Malvino. (Chapter 20)

Basic Electronics: A Text-Lab Manual. 5th Edition. Paul B. Zbar and Albert P. Malvino. (Experiment #40)

DUTY AREA

2. WORKING WITH AMPLIFIERS, OSCILLATORS, POWER SUPPLIES, AND ELECTRONIC DEVICES

PROGRAM

TASK/COMPETENCY

2.22 draw the I-V characteristic of an SCR

COURSE

2.22

PERFORMANCE OBJECTIVE

P 2.22 Given an SCR and the necessary tools and equipment, draw the I-V characteristic of the SCR for three (3) values of gate current and label all important points; the characteristic must show a decrease in anode to cathode voltage as the gate current increases when switching from off to on.

SELECTED ENABLING OBJECTIVES

E 2.22.1 Define thyrsitor.

E 2.22.2 Explain how thyristors differ from bipolar transistors and FETS and state their main applications.

E 2.22.3 Draw the schematic symbol for a Shockley diode and explain how to turn it on and off.

E 2.22.4 Give two (2) examples where a Shockley diode might be used.

E 2.22.5 Draw the schematic diagram for an SCR and explain the method used to turn it on and off.

E 2.22.6 Explain one method used to reduce the effect of switching transients in SCRs.

E 2.22.7 Explain what is meant by an SCR crowbar and state one application of the SCR crowbar.

E 2.22.8 Explain the operation of a photo-SCR (LASCR) and draw a schematic diagram illustrating one application of a LASCR.

E 2.22.9 Draw the schematic symbol for a GCS and a SCS, and define the meaning of each term.

E 2.22.10 List two (2) bidirectional thyristors, draw the schematic symbols for each, and state several applications for each.

E 2.22.11 Draw the schematic symbol for a UJT and explain the quantity intrinsic stand off ratio.

E 2.22.12 Explain how a UJT works and list several applications of a UJT.

E 2.22.13 Draw the schematic circuit for a UJT relaxation oscillator and explain how its frequency can be adjusted.

E 2.22.14 Conduct a laboratory experiment to determine how gate current is used to switch an SCR on and off and to verify that gate current levels may be used to control collector load current levels.

CRITERION-REFERENCED MEASURE

C 2.22 Draw the characteristics of the SCR for three (3) values of gate current and label all important points; the characteristics must show a decrease in anode to cathode voltage as gate current increases when switching from off to on.

SELECTED INSTRUCTIONAL ACTIVITIES

1. Demonstrate how to draw the schematic symbol for a diode, triode, tetrode, and pentode, and explain how to properly label each element - - point out that the filament is not normally included in the schematic symbol. (E 2.23.1)
2. Explain thermionic emission in terms of electrons being boiled off the cathode surface when heated. (E 2.23.2)
3. Discuss the operation of a vacuum tube diode, its main application as a rectifier, and provide a demonstration showing its operation. (E 2.23.3)
4. Discuss the action of the control grid in a triode and describe how it controls plate current. (E 2.23.4)
5. Demonstrate how to draw a simple triode amplifier showing the proper bias, the direction of electron flow and explain how phase inversion occurs. (E 2.23.5)
6. Discuss the action of the screen grid in a tetrode, emphasizing the bias on each element in the tube; explain why the tetrode is not widely used as an amplifier. (E 2.23.6)
7. Explain the purpose of the suppressor grid in a pentode and use the plate characteristic curves for a pentode to demonstrate the action of the suppressor grid and the amplification factor. (E 2.23.7)
8. Demonstrate how to draw a simple pentode amplifier circuit showing the proper bias, and the direction of electron flow. (E 2.23.8)
9. Demonstrate how to draw the schematic symbol for a beam power tube and give several examples of its application. (E 2.23.9)

SELECTED TOOLS AND MATERIALS

Vacuum tubes: diode, triode, tetrode, pentode, beam power
VTVM
Milliammeter
110 VAC 60Hz isolation transformer

SELECTED AUDIOVISUAL MATERIALS

SELECTED REFERENCES

Basic Electronic Principles. 3rd Edition. Albert P. Malvino. (Chapter 29)

DUTY AREA

DEMONSTRATING FABRICATION TECHNIQUES

TASK/COMPETENCY SEQUENCE

3.1 Demonstrate accepted soldering techniques

3.2 Make wire wrap connections

3.3 Construct a wire harness (interface)

3.4 Prepare shielded wire and coaxial cables for installation

3.5 Construct a P.C. board

3.6 Install components on a P.C. board

3.7 Demonstrate proper handling techniques for MOSFETS

3.8 Construct a chassis

DUTY AREA

3. DEMONSTRATING FABRICATION TECHNIQUES

PROGRAM

TASK/COMPETENCY

3.1 Demonstrate accepted soldering techniques

COURSE

3.1

PERFORMANCE OBJECTIVE

P 3.1 Given selected components, printed circuit (PC) boards, and soldering tools, demonstrate accepted soldering techniques by making a series of soldered connections in accordance with NASA NHB 5400.1.

SELECTED ENABLING OBJECTIVES

E 3.1.1 Explain the procedures used to clean and store soldering irons after use.

E 3.1.2 Complete a soldering safety test.

E 3.1.3 Demonstrate soldering techniques used to:

A. Solder solid and stranded wire to lugs, terminals, and connectors;
B. Solder descrete devices to P.C. boards(single-sided and double-sided with plated through holes); and
C. Solder integrated circuits (IC) and dual-in-line (DIP) components to a P.C. board.

E 3.1.4 Demonstrate techniques used to desolder:

A. Components from terminals,
B. Components from P.C. boards using wick and desoldering tools,
C. Cables (solid wire and stranded wire), and
D. Components and wires from a chassis.

E 3.1.5 Prepare wire (solid, stranded, cable, coaxial, and ribbon) for soldering.

CRITERION-REFERENCED MEASURE

C 3.1 Demonstrate accepted soldering techniques by making a series of soldered connections in accordance with NASA NHB 5400.1.

SELECTED INSTRUCTIONAL ACTIVITIES

1. Discuss safety practices for soldering. (E 3.1.2)
2. Have the students complete a soldering safety quiz. (E 3.1.2)
3. Explain the procedures used to prepare a soldering iron for use and for storage after use. (E 3.1.1)
4. Discuss and demonstrate techniques using 63/37 and 60/40 solder to solder:
    - A. Solid and stranded wire to lugs, terminals, and connectors,
    - B. Descrete devices to P.C. boards, and
    - C. Integrated circuits (IC) and dual-in-line (DIP) components to a P.C. board. (E 3.1.3)
5. Discuss and demonstrate techniques used to desolder:
    - A. Components from terminals,
    - B. Components from P.C. boards using wick and desoldering tools,
    - C. Cables (solid wire and stranded wire), and
    - D. Components and wires from a chassis. (E 3.1.4)
6. Display several types of wire that has been prepared for soldering. (E 3.1.5)
7. Demonstrate how to prepare stranded wire for soldering. (E 3.1.5)
8. Discuss the various techniques used on solid, cable, coaxial, and ribbon wiring. (E 3.1.5)

SELECTED TOOLS AND MATERIALS

Safety quiz
Soldering iron
Soldering aids
Holding device
Wire strippers
Diagonal cutters
Soldering iron stands
Solder (60/40 and 63/37)
NASA NHB 5400.1
Wire (solid, stranded, cable, coaxial, ribbon)
Terminals
Lugs and connectors
P.C. boards
Dual-in-line package (DIP)
Integrated circuits (IC)
Chassis with components and wires attached
Desoldering wick
Desoldering tool (solder vacuum type)

SELECTED AUDIOVISUAL MATERIALS

"Paces Soldering Program" (VCR tape)

SELECTED REFERENCES

Electronics Techniques: Shop Practice and Construction. Villanucci, Avigis, and Megow. (Chapter 15)

DUTY AREA

3. DEMONSTRATING FABRICATION TECHNIQUES

PROGRAM

TASK/COMPETENCY

3.2 Make wire wrap connections

COURSE

3.2

PERFORMANCE OBJECTIVE

P 3.2 Given wire wrap terminals, wire, wire wrap tools, and a P.C. board, mount the wire wrap terminals and make wire wrap connections in accorddance with NASA standards.

SELECTED ENABLING OBJECTIVES

E 3.2.1 Mount wire wrap terminals on a P.C. board.

E 3.2.2 Explain the difference between a type 1 and type 2 wire wrap.

E 3.2.3 List the three (3) types of coatings used on wire wrap wire.

E 3.2.4 Explain the relationship between wire size and the number of turns for a proper wire wrap.

E 3.2.5 Demonstrate making a wire wrap and a wire unwrap.

CRITERION-REFERENCED MEASURE

C 3.2 Make wire wrap connections in accordance with NASA standards.

SELECTED INSTRUCTIONAL ACTIVITIES

1. Display and discuss the types of wire-wrap terminals used on P.C. boards. (E 3.2.1)

2. Discuss the types and sizes of wire used for wire-wrap and list the types of coating used on the wire. (E 3.2.3)

3. Explain the relationship that exists between wire size and the number of turns per wrap, and discuss the two (2) types of wire-wraps and their purpose. (E 3.2.2 and E 3.2.4)

4. Demonstrate inserting wire-wrap terminals on a P.C. board and make a type 1 and type 2 wire wrap using different size wire for each. (E 3.2.1, E 3.2.2, and E 3.2.5)

5. Demonstrate how to unwrap a wire wrap. (E 3.2.5)

SELECTED TOOLS AND MATERIALS

Wire wrap terminals
Wire (AWG 18 thru 26)
Wire wrap tools
Dewrapping tools
Pre-printed, pre-punched P.C. board
NASA wire wrap standards
NASA NHB 5400.1

SELECTED AUDIOVISUAL MATERIALS

"Soldering Principles" (filmstrip), Bergwall Productions

SELECTED REFERENCES

Electronic Techniques: Shop Practices and Construction. Villanucci, Avigis, Megow. (Chapter 19)

DUTY AREA

3. DEMONSTRATING FABRICATION TECHNIQUES

PROGRAM

TASK/COMPETENCY

3.3 Construct a wire harness (interface)

COURSE

3.3

PERFORMANCE OBJECTIVE

P 3.3 Given a wire layout drawing, tools, and materials, construct a wire harness (interface); all wires in the harness must have identifying alphanumeric or color codes to indicate the wires' functions.

SELECTED ENABLING OBJECTIVES

E 3.3.1 Explain the difference between a harness and a cable.

E 3.3.2 Draw a harness layout.

E 3.3.3 Demonstrate how to splice a wire.

E 3.3.4 Explain how to measure wire size using a wire gauge.

E 3.3.5 Prepare wires for soldering.

E 3.3.6 List four (4) types of wire connections.

E 3.3.7 Terminate a wire run with a (solderless) crimp connection.

E 3.3.8 Insulate both splice and solderless connectors with heat shrink tubing.

E 3.3.9 Construct a wire harness jig.

E 3.3.10 Pot a multi-pin connector to a wire harness.

CRITERION-REFERENCED MEASURE

C 3.3 Construct a wire harness (interface); all wires in the harness must have identifying alphanumeric or color codes to indicate the wires' functions.

SELECTED INSTRUCTIONAL ACTIVITIES

1. Discuss the differences between a cable and a wire harness. (E 3.3.1)
2. Review techniques in drawing a wire harness layout. (E 3.3.2)
3. Discuss the various methods and types of connections used to splice wires. (E 3.3.3)
4. Explain the purpose of a wire gauge and demonstrate how to measure wires of various sizes. (E 3.3.4)
5. Display the various wire connections to include (solderless) crimp connections, explain the purpose and use of each. (E 3.3.6, E 3.3.7, and E 3.3.10)
6. Demonstrate the use of heat shrink tubing. (E 3.3.8)
7. Demonstrate mixing and potting a connector and terminate a wire run with a crimp connection and a potted connector. (E 3.3.6, E 3.3.7, and E 3.3.9)
8. Discuss the procedures used to prepare wires for soldering and demonstrate preparation for soldering wires. (E 3.3.5)
9. Review safety procedures to be employed while using tools and equipment. (E 3.3.3, E 3.3.5, E 3.3.7, and E 3.3.9)
10. Display a wire harness jig and discuss the procedures used to construct it. (E 3.3.9)

SELECTED TOOLS AND MATERIALS

Wire gauge
Wire ties
Waxed string
Wire
Shielded wire
Coaxial cable
Solderless connectors
Crimpers
Wire strippers
Heat shrink tubing
Cannon plus
Flatpac-terminals
Solder 60/40
Soldering irons
Soldering iron holders
Safety glasses
Solderless splices
Epoxy and potting compounds
Heat gun
Filmstrip cassette player

SELECTED AUDIOVISUAL MATERIALS

"Soldering Principles." Bergwall Co. (filmstrip)

SELECTED REFERENCES

Electronic Techniques: Shop Practices and Construction, Villanucci, Avigis, and Megow. (Chapter 20)

DUTY AREA

3. DEMONSTRATING FABRICATION TECHNIQUES

PROGRAM

TASK/COMPETENCY

3.4 Prepare shielded wire and coaxial cables for installation

COURSE

3.4

PERFORMANCE OBJECTIVE

P 3.4 Given shielded wire, coaxial cable, tools, and terminals, prepare the shielded wire and coaxial cable for installation by mounting terminals on each end of the shielded wire and coaxial cable in accordance with NASA soldering standards.

SELECTED ENABLING OBJECTIVES

E 3.4.1 Explain the difference between shielded wire and coaxial cable.

E 3.4.2 Demonstrate how to prepare shielded wire and coaxial cable for terminal installation.

E 3.4.3 Explain what "skin effect" is and what type of material is used to minimize "skin effect."

E 3.4.4 Solder a phono plug to a shielded wire and coaxial cable.

E 3.4.5 Connect a Bayonet Naval Connector (BNC) or other high frequency connector to a coaxial cable.

CRITERION-REFERENCED MEASURE

C 3.4 Prepare shielded wire and coaxial cable for installation by mounting terminals on each end of the shielded wire and coaxial cable in accordance with NASA soldering standards.

SELECTED INSTRUCTIONAL ACTIVITIES

1. Explain the difference between shielded wire and coaxial cable. (E 3.4.1)

2. Display several types of phono plugs and jacks and demonstrate how shielded wire and coaxial cable is prepared for a phono plug's installation. (E 3.4.2)

3. Review safety procedures for soldering and demonstrate proper techniques. (E 3.4.4)

4. Explain "skin effect" as the term applies to high frequency in a coaxial cable. (E 3.4.3)

5. Discuss the types of materials used to aid in preventing "skin effect." (E 3.4.3)

6. Demonstrate the connecting of a BNC connector or other high frequency connector to a coaxial cable. (E 3.4.5)

SELECTED TOOLS AND MATERIALS

Shielded cable
Coaxial cable
Phono plugs and jacks
Solder (60/40)
Soldering irons
BNC connector

Strippers
Scribes
Diagonal cutters
Long nose pliers
NASA soldering standards

SELECTED AUDIOVISUAL MATERIALS

SELECTED REFERENCES

Electronic Techniques: Shop Practices and Construction. Villanucci, Aviqis, and Megow. (Chapter 19)

DUTY AREA

PROGRAM

3. DEMONSTRATING FABRICATION TECHNIQUES

TASK/COMPETENCY

COURSE

3.5 Construct a P.C. board

3.5

PERFORMANCE OBJECTIVE

P 3.5 Given tools, materials, and a circuit schematic, construct a P.C. board for the circuit; the conductor patterns must pass a continuity check after etching.

SELECTED ENABLING OBJECTIVES

E 3.5.1 Explain the advantages of a P.C. board over a hard wired circuit.

E 3.5.2 List the classification of P.C. boards and explain how each is used.

E 3.5.3 Use "The Laminated Thermosetting Sheets Principle Grades, Uses and Properties Chart" to find the continuous operating temperature for NEMA grade G3 copper clad board.

E 3.5.4 List the approximate thickness of copper foil for 102, 202, and 302 foil plating.

E 3.5.5 Use "The Maximum Recommended Current-Carrying Capacity for Various Conductor Widths and Thicknesses Chart"to find the conductor width needed to carry 1.90 amps.

E 3.5.6 List the size grid systems used to layout circuit artwork at 4:1, 2:1, and 1:1 scale.

E 3.5.7 Explain the procedures used to develop the necessary artwork for a P.C. board.

E 3.5.8 Explain the effect of "capacitance" due to component and conductor spacing on the circuit board.

E 3.5.9 Explain procedures used to print and etch a single-side circuit board.

E 3.5.10 Complete a safety test on "use of corrosive acids."

E 3.5.11 Make a single-sided P.C. board of a specified circuit.

E 3.5.12 Develop a 4:1 artwork layout for a specified circuit.

CRITERION-REFERENCED MEASURE

C 3.5 Construct a P.C. board for a selected circuit; the conductor patterns must pass a continuity check after etching.

SELECTED INSTRUCTIONAL ACTIVITIES

1. Discuss the development of P.C. boards and their advantages over the hard wired circuit. (E 3.5.1)
2. List the various types and classifications of P.C. boards and discuss how each is used. (E 3.5.2)
3. Display and explain how to extract information from "The Laminated Thermosetting Sheets Principle Grades, Uses, and Properties Chart." (E 3.5.3 through E 3.5.5)
4. Discuss and demonstrate techniques used to develop artwork for a P.C. board, and display the tools and materials used in its development. (E 3.5.6 and E 3.5.12)
5. Have the students develop a 4:1 artwork layout. IE 3.5.6 and E 3.5.12)
6. Demonstrate the techniques used to place components and layout conductors to recommended spacing to prevent capacitance effect. (E 3.5.7 and E 3.5.8)
7. Discuss techniques used to print and etch a P.C. board and explain the safety steps to be taken when using, storing, and disposing of corrosive acids. (E 3.5.9 and E 3.5.10)
8. Have the students take a test on the "use of corrosive acids." (E 3.5.9 and E 3.5.10)
9. Have the students make a single-sided P.C. board of a specified circuit. (E 3.5.11)

SELECTED TOOLS AND MATERIALS

Grid paper (.050, 0.100, 0.125 per inch
Layout templets
Component outlines (dolls)
Artwork
Tapes (1/16 to 1/8 inch)
Elbows (30, 45, 60, 90)
IC pads "To" Type
Terminal pads
Donuts
Dip pads
Connector patterns
Transistor pads
Xacto knives
Drawing boards

SELECTED AUDIOVISUAL MATERIALS

Charts of:

A. Grades, uses, and properties of circuit boards,
B. Copper foil thickness by ounce per square foot, and
C. Maximum current per conductor width

SELECTED REFERENCES

Electronic Techniques: Shop Practices and Construction. Villanucci, Avigis, and Megow. (Chapters 10, 11, and 13)

DUTY AREA

3. DEMONSTRATING FABRICATION TECHNIQUES

PROGRAM

TASK/COMPETENCY

3.6 Install components on a P.C. board

COURSE

3.6

PERFORMANCE OBJECTIVE

P 3.6 Given a pre-drilled P.C. board, a block diagram of component placement, specified components, and tools, install components on the P.C. board; component placement must conform to the block diagram, including polarity, input-output pins, and positioning of components.

SELECTED ENABLING OBJECTIVES

E 3.6.1 Explain what criteria is used to determine if a component is flush mounted to the circuit board.

E 3.6.2 Demonstrate the proper methods used to bend axial component leads.

E 3.6.3 Explain the criteria used to determine the radius of bends for axial component leads.

E 3.6.4 Explain the difference between a clinched and service bend.

E 3.6.5 Mount components on a P.C. board demonstrating the proper procedure for mounting:

A. Transistors,
B. Heat sinks,
C. Resistors,
D. Axial capacitors, and
E. Disc capacitors.

E 3.6.6 Demonstrate how to install an axial component on high density boards.

CRITERION-REFERENCED MEASURE

C 3.6 Install components on the P.C. board; component placement must conform to the block diagram, including polarity, input-output, and component position.

SELECTED INSTRUCTIONAL ACTIVITIES

1. Discuss the criteria used to determine if a component can be flush mounted. (E 3.6.1 and E 3.6.5)

2. Discuss and demonstrate various techniques used to bend component leads. (E 3.6.2 and E 3.6.3)

3. Explain how to determine the radius of bends for component leads. (E 3.6.2 and E 3.6.3)

4. Explain what a clinched and a service bend is used for and demonstrate how each bend is made. (E 3.6.4)

5. Have the students mount components on a circuit board following recommended practices. (E 3.6.5)

6. Have the students place a resistor on the board in a manner used for high density boards. (E 3.6.6)

SELECTED TOOLS AND MATERIALS

Long nose pliers
Diagonal cutters
Heat sinks
Resistors
Transistors
Capacitors (axial and disc)
Mini-transformers
Solder (60/40)
Soldering irons
Soldering iron holders
Safety glass
Pre-drilled P.C. boards
Coils

SELECTED AUDIOVISUAL MATERIALS

SELECTED REFERENCES

Electronic Techniques: Shop Practices and Construction. Villanucci, Avigis, and Megow. (Chapter 14)

DUTY AREA

3. DEMONSTRATING FABRICATION TECHNIQUES

PROGRAM

TASK/COMPETENCY

3.7 Demonstrate proper handling techniques for MOSFETS

COURSE

3.7

PERFORMANCE OBJECTIVE

P 3.7 Given a P.C. board, MOSFET, and tools, mount the MOSFET on the P.C. board and demonstrate proper handling techniques for MOSFETS in accordance with the instruction sheet.

SELECTED ENABLING OBJECTIVES

E 3.7.1 Name the material used as an insulator between the gate and the channel in the MOSFET and compare this structure to the JFET gate.

E 3.7.2 Draw and label a block diagram of a MOSFET.

E 3.7.3 Explain the differences between a normally on and normally off MOSFET.

E 3.7.4 Demonstrate procedures used to ground yourself and assembly chassis prior to MOSFET installation.

E 3.7.5 Mount a MOSFET packaged in a TO and DIP configuration to a P.C. board.

CRITERION-REFERENCED MEASURE

C 3.7 Demonstrate proper handling techniques for MOSFETS in accordance with the MOSFET instruction sheet.

MOSFET 1 - INSTRUCTION SHEET

Techniques Used When Handling Metal-Oxide Field Effect Transistors

The metal-oxide semiconductor field effect transistor requires utmost care during circuit assembly. This device is very sensitive to minute static voltages. Because of this sensitivity MOSFETS must be protected during handling. Manufacturers have developed three (3) methods to do this: (1) a metal ring is placed around the MOSFET leads to electrically connect them; (2) the leads of the MOSFET are twisted together; or (3) the device is placed in a non-static blackfoam. These methods are effective in protecting MOSFETS but they are cumbersome when working on high density boards. The most accepted practice used to protect MOSFETS is to ground your body, the assembly chassis, and conductive work mat (Pink Polly). The following is a step-by-step procedure to follow.

1. Verify grounds in the lab.
2. Connect a low resistant lead from the ground to the work mat.
3. Connect the wrist (body) grounding strap to a 470K Ohm to 1M Ohm resistor. The free lead of the resistor is then connected to the work mat.
4. All chassis, transistors, or I.C. containers must be in contact with the work mat before the MOSFET is handled.
5. All tools used must be conductive and connected to the work mat.
6. Use only soldering irons with a three (3) prong plug.

NOTE: The following procedures are used for MOSFET installation in an ungrounded environment..

1. Devices with a metal ring around the leads:
    - A. Before removing the device from its packing, inspect it to insure the metal ring is in place and not damaged.
    - B. Insert leads into the P.C. board (Note: be sure there is sufficient room between the sealing plan and the P.C. board surface to allow access to the ring with diagonal cutters. DO NOT CUT THE RING AT THIS TIME!
    - C. Bend and trim the leads of the device.
    - D. Solder the leads of the device to the P.C. board (Note: remember to heat sink the leads during soldering to prevent thermal damage.)
    - E. Use miniature diagonal cutters to remove the metal ring from the leads. CAUTION: Care must be taken not to damage the leads during this operation.

2. Devices that have twisted leads:
   - A. Inspect the device to insure all leads are twisted together.
   - B. Identify each lead without untwisting the leads.
   - C. Carefully insert the leads into the proper holes up to the twist in the leads.
   - D. Bend and trim leads. DO NOT UNTWIST THE LEADS
   - E. Solder leads to the P.C. board and untwist the leads.

SELECTED INSTRUCTIONAL ACTIVITIES

1. Discuss the structure of a MOSFET and make a comparison to a JFET structure by using a block diagram to illustrate the structure. (E 3.7.1 and E 3.7.2)

2. Explain the difference between E-MOSFETS and DE-MOSFETS using the symbols of each to explain the "normally on," "normally off," concept. (E 3.7.3)

3. Demonstrate and explain techniques used to ground ones self and assembly chassis prior to handling and installing of an MOSFET. (E 3.7.4)

4. Have the students mount a MOSFET packaged in a TO and DIP configuration to a P.C. board following instructions on the MOSFET instruction sheet. (E 3.7.5)

SELECTED TOOLS AND MATERIALS

Pre-printed circuit boards
MOSFETS (1 per student)
Body grounding strap (1 per student)
Soldering irons
Solder (resin core 60/40)
Instruction sheets
MOSFET block diagram chart
MOSFET symbol chart (optional - - may be on the board)

SELECTED AUDIOVISUAL MATERIALS

SELECTED REFERENCES

Electronic Devices, Third Edition. Ronald J. Tocci. (Chapter 16)

Electronic Fabrication. Gordon Shimizu. (Chapter 4)

DUTY AREA

3. DEMONSTRATING FABRICATION TECHNIQUES

PROGRAM

TASK/COMPETENCY

3.8 Construct a chassis

COURSE

3.8

PERFORMANCE OBJECTIVE

P 3.8 Given a chassis assembly drawing, material, and tools, construct a chassis that meets the specified dimensions on the assembly drawing.

SELECTED ENABLING OBJECTIVES

E 3.8.1 Prepare a detailed drawing of a chassis layout.

E 3.8.2 Assemble hardware packages for chassis construction from the bill of materials.

E 3.8.3 Assemble structural members according to assembly drawings.

E 3.8.4 Make a chassis layout.

E 3.8.5 Demonstrate cutting bulk sheet stock into chassis blanks.

E 3.8.6 Demonstrate the proper use of a hand notcher.

E 3.8.7 Demonstrate the proper use of a Greenlee punch.

E 3.8.8 List types of tools and machines used to drill, ream, and punch holes in chassis blanks.

E 3.8.9 Demonstrate safe and proper techniques for bending chassis blanks.

E 3.8.10 Complete a safety test on a:

A. Squaring-shear,
B. Pan break,
C. Drill press, and a
D. Hand notcher.

E 3.8.11 Construct a thread block gauge.

CRITERION-REFERENCED MEASURE

C 3.8 Construct a chassis that meets the specified dimensions on assembly drawings.

SELECTED INSTRUCTIONAL ACTIVITIES

1. Discuss and review techniques of developing an assembly drawing. (E 3.8.1 and E 3.8.2)
2. Display completed layouts and explain how a bill of material is developed. (E 3.8.1 and E 3.8.2)
3. Display a chassis blank that has been dyed and layed out and discuss the techniques used by demonstrating, on the blackboard how lines, circles, and bends are layed out. (E 3.8.4)
4. Discuss the safety precautions used while operating shop machines and hand tools. (E 3.8.5 through E 3.8.10)
5. Discuss and demonstrate the proper operation of a:
   A. Squaring-shear,
   B. Pan and/or finger brake,
   C. Drill press,
   D. Notcher, and
   E. Greenlee punch, and administer the appropriate safety tests. (E 3.8.5 through E 3.8.9)
6. Explain and demonstrate various methods for assembling structural members. (E 3.8.3)
7. Display and discuss how to construct a thread block gauge. (E 3.8.11)
8. Explain how to determine drill bit size for a specified "tap." (E 3.8.11)
9. Demonstrate the proper use of a tap to thread a hole. (E 3.8.11)

SELECTED TOOLS AND MATERIALS

Bulk sheet stock (gauge selected by the instructor)
Layout dye
Scribes
T-square
Triangles (30-60 and 45-90)
Circle templets
Teacher made safety tests

Drill press
Drills
Taps
Tap holder
Squaring shear
Greenlee punch
Pan or finger brake

SELECTED AUDIOVISUAL MATERIALS

SELECTED REFERENCES

Electronic Techniques: Shop Practices and Construction," Second Edition. Villanucci, Avtgis, and Megow. (Chapters 1 and 3 through 9)

DUTY AREA

COMMUNICATING TECHNICAL INFORMATION

TASK/COMPETENCY SEQUENCE

4.1 Identify schematic symbols for electronic components

4.2 Interpret mechanical blueprints

4.3 Prepare mechanical drawings

4.4 Prepare an assembly layout drawing

4.5 Prepare electronic drawings

4.6 Prepare pictorial drawings

4.7 Interpret blueprint scales

4.8 Prepare a wire routing sheet

4.9 Translate charts and graphs

4.10 Use manufacturer's service literature and parts catalogs

DUTY AREA

4. COMMUNICATING TECHNICAL INFORMATION

PROGRAM

TASK/COMPETENCY

4.1 Identify schematic symbols
for electronic components

COURSE

4.1

PERFORMANCE OBJECTIVE

P 4.1 Given twenty (20) electronic components and a list of schematic symbols, correctly identify the schematic symbols for the components.

SELECTED ENABLING OBJECTIVES

E 4.1.1 Explain the purpose of schematic diagrams.

E 4.1.2 Sketch symbols for electronic components.

E 4.1.3 Select designated components from a schematic diagram.

E 4.1.4 Explain the purpose of electronic symbols used in diagrams.

CRITERION-REFERENCED MEASURE

C 4.1 Correctly identify all twenty (20) schematic symbols for the components.

SELECTED INSTRUCTIONAL ACTIVITIES

1. Discuss the need for schematic symbols and how they simplify electrical schematic diagrams. (E 4.1.1)
2. Display components and discuss their schematic symbols. (E 4.1.4)
3. Demonstrate sketching of electronic symbols. (E 4.1.2)
4. Discuss and compare components and the similarities and differences of their schematic symbols. (E 4.1.3 and E 4.1.4)

SELECTED TOOLS AND MATERIALS

Radio chasis (portable) or TV chasis or equivalent electronic circuit board
Schematic diagrams
Electronic components (resistors, capacitors, transformers, diodes, vacuum tubes, or other components available in the lab)

SELECTED AUDIOVISUAL MATERIALS

"Electronic Component Symbols" (wall chart)

SELECTED REFERENCES

Electrical and Electronics Drawing. 5th Edition. Charles J. Baer and John R. Ottaway. (Chapter 3)

American National Standards Institute Standards (ANSI) Guide

Institute of Electrical and Electronic Engineers Standards (IEEE) Guide

DUTY AREA

4. COMMUNICATING TECHNICAL INFORMATION

PROGRAM

TASK/COMPETENCY

4.2 Interpret mechanical blueprints

COURSE

4.2

PERFORMANCE OBJECTIVE

P 4.2 Given a list of ten (10) mechanical components and a blueprint, interpret the blueprint by locating all ten (10) components on the list.

SELECTED ENABLING OBJECTIVES

E 4.2.1 Explain the purpose of mechanical blueprints.

E 4.2.2 Describe the symbols on blueprints used to represent components.

E 4.2.3 Describe the process of making a blueprint.

E 4.2.4 Make a blueprint from a mechanical drawing.

E 4.2.5 Explain the difference between a blueprint and a white print.

E 4.2.6 List the information found in a blueprint title block.

CRITERION-REFERENCED MEASURE

C 4.2 Interpret the blueprint by locating the ten (10) components on the list.

SELECTED INSTRUCTIONAL ACTIVITIES

1. Discuss the purpose of blueprints and review schematic symbols. (E 4.2.1 and E 4.2.2)
2. Explain and demonstrate the process of making a blueprint. (E 4.2.3 and E 4.2.4)
3. Display and discuss a blueprint and white print, pointing out their differences and telling how/when each is used. (E 4.2.5)
4. Explain the information found in the title block of a blueprint. (E 4.2.6)

SELECTED TOOLS AND MATERIALS

Whiteprinter
Blueprinter
Mechanical drawings
Schematic symbols chart

SELECTED AUDIOVISUAL MATERIALS

SELECTED REFERENCES

Electrical and Electronics Drawing. 5th Edition. Charles J. Baer and John R. Ottaway. (Chapter 4)

DUTY AREA

4. COMMUNICATING TECHNICAL INFORMATION

PROGRAM

TASK/COMPETENCY

4.3 Prepare mechanical drawings

COURSE

4.3

PERFORMANCE OBJECTIVE

P 4.3 Given an actual mechanical assembly and drafting tools, prepare mechanical drawings showing three (3) views of the assembly and a half-section view, in accordance with ANSI standards.

SELECTED ENABLING OBJECTIVES

E 4.3.1 Explain the purpose, application, and fundamental concepts of orthographic drawings.

E 4.3.2 Make an orthographic projection of an object.

E 4.3.3 Explain the purpose and application of a half-section drawing.

E 4.3.4 Draw a half-section of a mechanical assembly.

E 4.3.5 List the six (6) views of an orthographic projection.

E 4.3.6 Explain dimensioning techniques used for orthographic projection.

E 4.3.7 Dimension an orthographic projection.

E 4.3.8 List the ANSI standards for orthographic projections and half-views.

CRITERION-REFERENCED MEASURE

C 4.3 Prepare mechanical drawings of a mechanical assembly showing three (3) views of the assembly and a half-section view, in accordance with ANSI standards.

SELECTED INSTRUCTIONAL ACTIVITIES

1. Discuss and explain the purpose of orthographic projections and give examples of how they are used. (E 4.3.1 and E 4.3.5)
2. Demonstrate how to develop an orthographic projection. (E 4.3.2)
3. Explain the purpose of, and demonstrate the development of, half-section drawings. (E 4.3.3 and E 4.3.4)
4. Explain and demonstrate dimensioning of orthographic projections. (E 4.3.7)
5. List the ANSI standards for orthographic projections and half-sections. (E 4.3.8)
6. Demonstrate how to use the ANSI guide. (E 4.3.8)

SELECTED TOOLS AND MATERIALS

Scales (engineering)
Triangles (30-60 and 45-90)
T-squares

SELECTED AUDIOVISUAL MATERIALS

SELECTED REFERENCES

Electrical and Electronics Drawing. 5th Edition. Charles J. Baer and John R. Ottaway. (Chapter 4)

Basic Technical Drawing. 8th Edition. I. Leroy Hill, F.E. Giesecke, and A. Mitchell. (Chapter 6 and 17)

ANSI Standards Guide

DUTY AREA

4. COMMUNICATING TECHNICAL INFORMATION

PROGRAM

TASK/COMPETENCY

4.4 Prepare an assembly layout drawing

COURSE

4.4

PERFORMANCE OBJECTIVE

P 4.4 Given mating mechanical parts, prepare an assembly layout drawing that meets ANSI Standard Y 14.3.

SELECTED ENABLING OBJECTIVES

E 4.4.1 List ANSI standards for assembly layout drawings.

E 4.4.2 Explain the purpose of an assembly layout drawing.

E 4.4.3 Identify schematic symbols used for mechanical parts.

E 4.4.4 Demonstrate methods used for component positioning in layout drawings.

E 4.4.5 Explain the coding and numbering systems used to indicate values of parts (components).

E 4.4.6 Freehand sketch an assembly drawing.

E 4.4.7 Demonstrate:

A. Scaling,
B. Enlarging, and
C. Reducing drawings.

E 4.4.8 Explain the relationship between schematic and assembly layout.

CRITERION-REFERENCED MEASURE

C 4.4 Prepare an assembly layout drawing that meets ANSI Standard Y 14.3.

SELECTED INSTRUCTIONAL ACTIVITIES

1. Discuss assembly layout drawings and their purpose. (E 4.4.1, E 4.4.2, and E 4.4.5)
2. Discuss the use of ANSI standards and coding and numbering systems. (E 4.4.1, E 4.4.2, and E 4.4.5)
3. Review symbols used to represent mechanical parts. (E 4.4.3)
4. Demonstrate techniques employed to freehand sketch an assembly layout. (E 4.4.4 and E 4.4.6)
5. Demonstrate methods used to determine component positioning in layouts. (E 4.4.4 and E 4.4.6)
6. Discuss schematics and their relationship to layout drawings. (E 4.4.8)
7. Discuss methods and techniques used to:
    - A. Scale,
    - B. Enlarge, or
    - C. Reduce drawings. (E 4.4.7)

SELECTED TOOLS AND MATERIALS

T-squares
Triangles (30-60 and 45-90)
Engineering drawing symbols chart
ANSI standard Y 14.3

SELECTED AUDIOVISUAL MATERIALS

SELECTED REFERENCES

Electrical and Electronics Drawing. 5th Edition. Charles J. Baer and John R. Ottaway. (Chapter 4)

Basic Technical Drawing. 8th Edition. I. Leroy Hill, F.E. Giesecke, and A. Mitchell. (Chapter 14)

DUTY AREA

4. COMMUNICATING TECHNICAL INFORMATION

PROGRAM

TASK/COMPETENCY

4.5 Prepare electronic drawings

COURSE

4.5

PERFORMANCE OBJECTIVE

P 4.5 Given a P.C. board with mounted components, prepare an electronic drawing of the P.C. board; the drawing must show proper component layout, source (power) input, and circuit (power) output.

SELECTED ENABLING OBJECTIVES

E 4.5.1 Make a free hand sketch of a block and logic diagram, and a circuit schematic.

E 4.5.2 Using drafting tools, make a block and logic diagram, and a circuit schematic.

E 4.5.3 List ANSI and IEEE standards for a block and logic diagram, and a circuit schematic.

E 4.5.4 Explain the purpose of the schematic diagram.

CRITERION-REFERENCED MEASURE

C 4.5 Prepare an electronic drawing showing component layout, source (power) input and circuit (power) output.

SELECTED INSTRUCTIONAL ACTIVITIES

1. Review free hand sketching techniques. (E 4.5.1)
2. Discuss block and logic diagrams, and circuit schematics; explaining the purpose of each. (E 4.5.2 through E 4.5.4)
3. Demonstrate the development of block and logic diagrams, and circuit schematics. (E 4.5.2 through E 4.5.4)
4. List ANSI standards for block and logic diagrams, and circuit schematics.

SELECTED TOOLS AND MATERIALS

T-squares
Triangles (30-60 and 45-90)
Engineering drawing symbols chart

SELECTED AUDIOVISUAL MATERIALS

SELECTED REFERENCES

Electrical and Electronics Drawing. 5th Edition. Charles J. Baer and John R. Ottaway. (Chapter 4)

ANSI Standards Guide

IEEE Standards Guide

DUTY AREA

PROGRAM

4. COMMUNICATING TECHNICAL INFORMATION

TASK/COMPETENCY

COURSE

4.6 Prepare pictorial drawings

4.6

PERFORMANCE OBJECTIVE

P 4.6 Given a mechanical device, prepare a pictorial drawing of an exploded view of the device in accordance with ANSI Standards.

SELECTED ENABLING OBJECTIVES

E 4.6.1 List the differences between isometric and oblique drawings.

E 4.6.2 List the base angle for dimetric drawings.

E 4.6.3 Explain the difference between a perspective, isometric, oblique, and dimetric drawing.

E 4.6.4 Freehand sketch an oblique drawing of a mechanical assembly.

E 4.6.5 Draw an isometric, dimetric, and perspective drawing of a mechanical or electrical part using drafting tools.

E 4.6.6 Prepare a pictorial drawing for use as an assembly guide.

CRITERION-REFERENCED MEASURE

C 4.6 Prepare a pictorial drawing of an exploded view of a mechanical device in accordance with ANSI Standards.

SELECTED INSTRUCTIONAL ACTIVITIES

1. Explain isometric, oblique, dimetric, and perspective drawings. (E 4.6.1 through E 4.6.3)
2. Demonstrate techniques used to develop an isometric, oblique, dimetric, and perspective drawing. (E 4.6.5)
3. Review freehand sketching and demonstrate freehand sketching of an oblique drawing. (E 4.6.4)
4. Demonstrate the development of a pictorial assembly drawing. (E 4.6.6)

SELECTED TOOLS AND MATERIALS

T-squares
Triangles (30-60 and 45-90)
An assortment of mechanical and electrical parts

SELECTED AUDIOVISUAL MATERIALS

SELECTED REFERENCES

Electrical and Electronics Drawing. 5th Edition. Charles J. Baer and John R. Ottaway. (Chapter 2)

ANSI Standards

DUTY AREA

4. COMMUNICATING TECHNICAL INFORMATION

PROGRAM

TASK/COMPETENCY

4.7 Interpret blueprint scales

COURSE

4.7

PERFORMANCE OBJECTIVE

P 4.7 Given a blueprint and measuring devices, interpret the blueprint scale and use the scale to determine the size and location of selected components; all dimensions must conform to the blueprint scale.

SELECTED ENABLING OBJECTIVES

E 4.7.1 Read and interpret English and metric scales used on blueprints.

E 4.7.2 Select the proper scale for the drawing of a mechanical assembly.

E 4.7.3 Scale a drawing using the English system.

E 4.7.4 Scale a drawing using the metric system.

CRITERION-REFERENCED MEASURE

C 4.7 Interpret the blueprint scale and use the scale to determine the size and location of selected components; all dimensions must conform to the blueprint scale.

SELECTED INSTRUCTIONAL ACTIVITIES

1. Discuss the measurement units used to scale drawings. (E 4.7.1)
2. Explain the need to scale in the metric as well as the English system. (E 4.7.1)
3. Discuss scientific notations and demonstrate conversion of numbers to scientific notations. (E 4.7.1)
4. Demonstrate scaling drawings using both the English and the metric system. (E 4.7.3 and E 4.7.4)

SELECTED TOOLS AND MATERIALS

Scales (metric and English)

SELECTED AUDIOVISUAL MATERIALS

SELECTED REFERENCES

Electrical and Electronics Drawing. 5th Edition. Charles J. Baer and John R. Ottaway. (Chapter 4)

DUTY AREA

4. COMMUNICATING TECHNICAL INFORMATION

PROGRAM

TASK/COMPETENCY

4.8 Prepare a wire routing sheet

COURSE

4.8

PERFORMANCE OBJECTIVE

P 4.8 Given a chassis with components mounted on it, prepare a wiring route sheet for component connection; each wire must be coded by color or alphanumeric symbols, in accordance with ANSI Y 14.15 and Military Standard (Mil Std) 681.

SELECTED ENABLING OBJECTIVES

E 4.8.1 Explain the four (4) types of wiring diagrams (point to point, highway, and truckline, baseline, or airline).

E 4.8.2 Define the terms:

A. Breakout,
B. Breakout point,
C. Fan out,
D. Lead,
E. Leg,
F. Trunk,
G. Harness contour,
H. Wire run, and
I. Lacing.

E 4.8.3 Develop an overlay of wire paths using a full scale chassis layout.

E 4.8.4 List the information found on a tabular form of wire identification and routing tables.

E 4.8.5 Explain the methods used to identify wires.

E 4.8.6 Develop a wiring diagram from a schematic.

CRITERION-REFERENCED MEASURE

C 4.8 Prepare a wire route sheet for component connection; wires must be coded by color or alphanumeric codes in accordance with ANSI Y 14.15 and Mil Std 681.

SELECTED INSTRUCTIONAL ACTIVITIES

1. Display and discuss samples of the four (4) types of wiring diagrams (point to (point to point, highway, and truckline, baseline, and airline). (E 4.8.1)

2. Using an actual wiring harness, point out and explain each of the following as they are displayed on the harness:

   A. Breakout
   B. Breakout point,
   C. Fan out,
   D. Lead,
   E. Leg,
   F. Trunk,
   G. Harness contour,
   H. Wire run, and
   I. Lacing. (E 4.8.2)

3. Explain the difference between a schematic and a wiring diagram. (E 4.8.6)

4. Demonstrate the development of a wire diagram from a schematic. (E 4.8.6)

5. Demonstrate making a preliminary sketch of a wire layout on an overlay using a full scale mechanical layout drawing. (E 4.8.3)

6. Discuss the wire coding chart displayed, and the information listed in the wire identification and routing tables. (E 4.8.4 and E 4.8.5)

SELECTED TOOLS AND MATERIALS

Drawings (point to point, highway, baseline, and straightline wire diagrams)
Wiring harness
Samples of lacing material
Tracing paper
Full scale mechanical layout drawing (electronic system of instructor's choice)
Chart for wire coding and routing table information
Electronic system schematics
ANSI standard Y 14.5
Mil Std 681

SELECTED AUDIOVISUAL MATERIALS

SELECTED REFERENCES

Electrical and Electronic Drawing. 5th Edition. Charles J. Baer and John R. Ottaway. (Chapter 4)

Electronic Techniques: Shop Practices and Construction. Villanucci, Avtgis, and Megow. (Chapter 20)

DUTY AREA

4. COMMUNICATING TECHNICAL INFORMATION

PROGRAM

TASK/COMPETENCY

4.9 Translate charts and graphs

COURSE

4.9

PERFORMANCE OBJECTIVE

P 4.9 Given the requirements to select a transistor with a specified "beta" and transistor characteristic curve charts, interpret the charts and select the transistor that meets the specified requirements.

SELECTED ENABLING OBJECTIVES

E 4.9.1 List the basic types of graphs and explain their purposes.

E 4.9.2 Develop a data table from data extracted from a chart/graph.

E 4.9.3 Extract specified data from a semi-logarithmic graph.

E 4.9.4 Plot a line of best fit for imperfect data.

E 4.9.5 Draw a line chart for given data.

E 4.9.6 Demonstrate methods of scaling and titling a chart/graph.

CRITERION-REFERENCED MEASURE

C 4.9 Interpret the charts and select the transistor that meets the specified requirements.

SELECTED INSTRUCTIONAL ACTIVITIES

1. Discuss the basic types of charts and graphs and explain their purposes. (E 4.9.1)
2. Demonstrate how data is extracted from a chart and developed into a table. (E 4.9.2 and E 4.9.3)
3. Discuss the various scales used on graphs and charts. (E 4.9.6)
4. Explain how to develop a title block and list the information normally found in that block. (E 4.9.6)
5. Discuss logarithmic and triangular coordinate paper, explain the purpose of each, and how data is plotted on each. (E 4.9.3)
6. Demonstrate how to develop a line of best fit for imperfect data. (E 4.9.4)

SELECTED TOOLS AND MATERIALS

Logarithmic paper
Triangular coordinated paper
Samples of pie, bar, and line charts
Scales

SELECTED AUDIOVISUAL MATERIALS

SELECTED REFERENCES

Electrical and Electronic Drawing, 5th Edition. Charles J. Baer and John R. Ottaway. (Chapter 4)

Electronic Techniques: Shop Practices and Construction. Villanucci, Avtgis, and Megow. (Chapter 11)

DUTY AREA

PROGRAM

4. COMMUNICATING TECHNICAL INFORMATION

TASK/COMPETENCY

COURSE

4.10 Use manufacturer's service literature and parts catalogs

4.10

PERFORMANCE OBJECTIVE

P 4.10 Given the description of a malfunction in a mechanical assembly, use the manufacturer's service manual to research the probable cause of a malfunction and the parts catalog to locate the part number for requisitioning purposes; all malfunctions and part numbers must be identified.

SELECTED ENABLING OBJECTIVES

E 4.10.1 List the major sections of a service manual.

E 4.10.2 List the probable cause for three (3) specified malfunctions using the service manual.

E 4.10.3 Explain what an exploded view is and how each part is labeled for cross referencing to a parts list.

E 4.10.4 Demonstrate how to use a cross reference catalog to locate suitable substitutes for parts.

CRITERION-REFERENCED MEASURE

C 4.10 Use the manufacturer's service manual to research the probable cause of a malfunction and the parts catalog to locate the part number for requisitioning purposes; all malfunctions and part numbers must be identified.

SELECTED INSTRUCTIONAL ACTIVITIES

1. Discuss the structure of a typical service/operations manual, and list the most commonly used sections of the manual: (a) General Information, (b) Installation and Operation, (c) Specifications or Principles of Operation, and (d) Maintenance and Parts List. (E 4.10.1)

2. Demonstrate how to use the maintenance troubleshooting section to find the probable cause of a malfunction. (E 4.10.2)

3. Display an exploded view of an assembly and explain how to locate a part and use its reference number to find the part number. (E 4.10.3)

4. Explain how to use a cross reference guide to locate a suitable substitute part. (E 4.10.4)

SELECTED TOOLS AND MATERIALS

Exploded view of an assembly

SELECTED AUDIOVISUAL MATERIALS

SELECTED REFERENCES

Manufacturer's service/operations manual and parts catalogs
Cross reference guides

DUTY AREA

DEMONSTRATING A.C. KNOWLEDGE

TASK/COMPETENCY SEQUENCE

5.1 Define the characteristics of A.C.

5.2 Calculate current ratio

5.3 Calculate inductive reactance

5.4 Calculate the phase angle in RL circuits

5.5 Calculate total capacitance

5.6 Calculate capacitive reactance

5.7 Calculate circuit parameters

5.8 Calculate RC and L/R time constant

5.9 Calculate impedance of RLC circuits

5.10 Apply complex numbers in A.C. circuit calculations

5.11 Compute Kirchhoff's laws for network analysis of A.C. circuits

5.12 Compute V Thevenin and I Norton for network analysis of A.C. circuits

5.13 Analyze series and parallel resonant circuits

5.14 Analyze filter circuits

DUTY AREA

5. DEMONSTRATING A.C. KNOWLEDGE

PROGRAM

TASK/COMPETENCY

5.1 Define the characteristics of A.C.

COURSE

5.1

PERFORMANCE OBJECTIVE

P 5.1 Given a voltage value of 110 VAC at 60 HERTZ, define the characteristics of A.C. by plotting instantaneous voltages at 30°, 45°, 60°, and 90°; computations for voltage plots must be done using the formula $V=V_M$sin Theta and must be within ±1% of instructor calculated values.

SELECTED ENABLING OBJECTIVES

E 5.1.1 Define D.C. characteristics.

E 5.1.2 Define A.C. current characteristics.

E 5.1.3 Develop a comparison chart for D.C. and A.C. voltage.

E 5.1.4 Perform an experiment on the "oscilloscope operation-triggered scope."

E 5.1.5 Explain:

- A. Peak voltage,
- B. Average voltage,
- C. Root-Mean-Square (RMS) voltage, and
- D. Peak-to-Peak voltage

E 5.1.6 Perform an experiment to measure voltage and current:

- A. Peak,
- B. RMS, and
- C. Average values of A.C.

E 5.1.7 Calculate instantaneous voltage for specified points on a sine wave.

E 5.1.8 Calculate the frequency, period, and wavelength of a sine wave.

E 5.1.9 Define phase angle.

E 5.1.10 Draw a sine wave and cosine wave on the same XY axis and use a phasor diagram to show the phase angle relationships between the two.

E 5.1.11 State the angle, in degree and radians for a:

- A. One-cycle,
- B. One-half cycle,
- C. One-quarter cycle, and
- D. Three-quarter cycle.

E 5.1.12 State audio and radio ranges in Hz.

E 5.1.13 Define harmonic frequencies, giving numerical values.

CRITERION-REFERENCED MEASURE

C 5.1 Define the characteristics of A.C. by plotting instanteous voltages at 30°, 45°, 60°, and 90°; computations for voltage plots must be done using the formula $V=V_m$sin calculated values.

SELECTED INSTRUCTIONAL ACTIVITIES

1. Explain the characteristics of D.C. and A.C. (E 5.1.1 and E 5.1.2)
2. Display a chart listing the comparison of D.C. and A.C. voltages. (E 5.1.3)
3. Explain the relationship between A.C. voltage and A.C.current in a resistive circuit. (E 5.1.4)
4. Explain instantaneous voltage and work out some problems on the board for Theta 30°, 45°, 90°, and 270°. (E 5.1.7)
5. Discuss the characteristics of, and demonstrate how to calculate the peak, peak-to-peak, average, and RMS value of a sine wave. (E 5.1.5)
6. Explain:
    A. Peak,
    B. Average, and
    C. RMS voltage. (E 5.1.5)
7. Demonstrate the use of an oscilloscope and have students perform an experiment operating a triggered sweep oscilloscope. (E 5.1.4)
8. Have students perform an experiment to measure peak and RMS voltages. (E 5.1.6)
9. Discuss the formulas used to calculate frequency, period, and wave length and explain the symbols used for each. (E 5.1.8)
10. Discuss units of time. (E 5.1.8)
11. Explain radians and their relationship to cycle. (E 5.1.9 through E 5. 1.11)
12. Explain phasor diagrams. (E 5.1.9 and E 5.1.10)
13. Discuss the different frequency ranges of A.C. (E 5.1.12)
14. Explain harmonics. (E 5.1.13)

SELECTED TOOLS AND MATERIALS

Overhead projector
120 VAC power source
120 V/60Hz isolation transformer
Oscilloscope
Variac
Triggered-type oscilloscope
Variable AF sine-wave generator
Digital electron volt meter (EVM)
SPST switch
Fused line cord
Resistors (½ watt - 2 each of 33 ohms, 2 each of 47 ohms, 2 each of 1000 ohms, and 2 each of 1500 ohms)

SELECTED AUDIOVISUAL MATERIALS

(Note: the following transparencies must be made by the teacher; no masters are provided)

"Waveform of D.C. and A.C." (transparency)
"Comparison Chart of D.C. and A.C. Current" (transparency)
"Formula for Instantaneous Voltage" (transparency)
"Formula for Peak Voltage" (transparency)
"Formula for AVG Voltage" (transparency)
"Formula for RMS Voltage" (transparency)
"Formula for Wave Length" (transparency)
"Formula for Frequency" (transparency)
"Formula for Period" (transparency)

SELECTED REFERENCES

Basic Electronics. 5th Edition. Bernard Grob. (Chapter 16)

Basic Electricity: A Text-Lab Manual. Paul B. Zbar. (Experiments #37 and #40)

Introductory Circuit Analysis. 4th Edition. Robert L. Boylestad. (Chapter 13, Experiments #37 and 40)

DUTY AREA

5. DEMONSTRATING A.C. KNOWLEDGE

PROGRAM

TASK/COMPETENCY

5.2 Calculate current ratio

COURSE

5.2

PERFORMANCE OBJECTIVE

P 5.2 Given an A.F. transformer with a 1:6 ratio and 760V across 7200 Ohms in the secondary, calculate I_s and I_p of an A.F. power transformer; the calculations must be reflective of voltage ratios in transformers.

SELECTED ENABLING OBJECTIVES

E 5.2.1 Explain how mutual induction induces voltage in an inductor.

E 5.2.2 Explain Lenz' Law.

E 5.2.3 Draw the schematic symbols for air core and iron core transformers.

E 5.2.4 List five (5) types of transformers.

E 5.2.5 Calculate mutual inductance of two (2) coils wrapped on a common core.

E 5.2.6 Calculate the turns ratio of a power transformer.

E 5.2.7 Define eddy currents and hysteresis.

E 5.2.8 List the color codes and their meanings for R.F. and power transformers.

E 5.2.9 Calculate voltage ratio, current ratio, power in the secondary, and transformer efficiency of an A.F. transformer.

E 5.2.10 List types of cores used for transformer construction.

E 5.2.11 Conduct an experiment on an A.F. transformer as specified.

E 5.2.12 Calculate the total inductance for both series and parallel connected inductors.

CRITERION-REFERENCED MEASURE

C 5.2 Calculate I_s and I_p of an A.F. power transformer; calculations must be reflective of voltage ratios in transformers.

SELECTED INSTRUCTIONAL ACTIVITIES

1. Explain Lenz' Law. (E 5.2.2)
2. Discuss mutual inductance and explain the coefficient of coupling. (E 5.2.1 and E 5.2.5)
3. Work problems of mutual inductance and coefficient of coupling. (E 5.2.1 and E 5.2.5)
4. Explain the construction of tranformers, discuss the types of cores used, and draw the schematic symbols for air core and iron core transformers. (E 5.2.3. and E 5.2.10)
5. Discuss the different types of transformers, R.F. and A.F. power, and list several of each type. (E 5.2.4 and E 5.2.6)
6. Explain how to calculate the turns ratio of a A.F. power transformer (TURNS RATIO = NP/NS). (E 5.2.4 and E 5.2.6)
7. Discuss core losses and explain "eddy currents" and "hysteresis." (E 5.2.7)
8. Display a power transformer and an R.F. transformer and discuss the wire color codes on each. (E 5.2.8)
9. Demonstrate how to use the various formula to calculate voltage ratio, current ratio, power in the secondary, and transformer efficiency. (E 5.2.9)
10. Have the students conduct an experiment to determine:
    A. The turn ratio of a given transformer;
    B. The effect of an increase current in the secondary on current in primary; and
    C. The continuity of the winding versus rated values. (E 5.2.11)
11. Demonstrate how to calculate total inductance in series and parallel circuits. (E 5.2.12)

SELECTED TOOLS AND MATERIALS

Power supply source (120V, 60Hz)
Transformers (A.F., ouput)
SPST switch
Overhead projector
EVM
Multirange AC millammeter
Decade type rheostat
Ohmmeter

SELECTED AUDIOVISUAL MATERIALS

(The following transparencies must be made by the teacher; no masters are provided)

"Exploded View of a Transformer" (transparency)
"Types of R.F. and A.F. Power Transformers" (transparency)
"Formula for Coefficient Coupling" (transparency)
"Formula for Turns Ratio" (transparency)
"Formula for Voltage Ratio" (transparency)
"Formula for Current Ratio" (transparency)
"Formula for Power in the Secondary" (transparency)
"Formula for Transformer Efficiency" (transparency)

SELECTED REFERENCES

Basic Electronics. 5th Edition. Bernard Grob. (Chapter 17)

Basic Electricity: A Text-Lab Manual. Paul B. Zbar. (Experiment #44)

Introductory Circuit Analysis, 4th Edition. Robert L. Boylestad. (Chapter 10)

DUTY AREA

5. DEMONSTRATING A.C. KNOWLEDGE

PROGRAM

TASK/COMPETENCY

5.3 Calculate inductive reactance

COURSE

5.3

PERFORMANCE OBJECTIVE

P 5.3 Given several values of inductance, calculate the value of the inductive reactance for each, when a sine wave of 1000 Hz is applied across each; all calculated values must agree within ±1% of the instructor calculated values.

SELECTED ENABLING OBJECTIVES

E 5.3.1 Define inductive reactance X_L and state its unit of measure.

E 5.3.2 Explain how X_L reduce the amount of A.C. current.

E 5.3.3 Explain the effect of L and F on X_L.

E 5.3.4 Calculate the value of X_L for several different values of L and f.

E 5.3.5 Calculate the value of f when X_L and L are given.

E 5.3.6 State two differences and one similarity between X_L and R.

E 5.3.7 Write the formula used to calculate the total X_L for inductors connected in series and in parallel.

E 5.3.8 Explain why X_L applies only to sine waves.

E 5.3.9 Explain why V_L and I_L are 90° out-of-phase.

E 5.3.10 Conduct and experiment to verify the L_T of a series and a parallel circuit.

CRITERION-REFERENCED MEASURE

C 5.3 Calculate the value of the inductive reactance when a sine wave of 1000 Hz is applied; all calculated values must agree within ±1% of the instructor calculated values.

SELECTED INSTRUCTIONAL ACTIVITIES

1. Review Lenz' law. (E 5.3.1 through E 5.3.5)
2. Explain inductive reactance, its unit of measure, and its effect on A.C. current. (E 5.3.1 and E 5.3.2)
3. Explain the inductive reactance formula its use in calculating X_L f and L. (E 5.3.3 through E 5.3.5)
4. Demonstrate the differences and the similarities between X_L and R. (E 5.3.6)
5. Explain the formula used to calculate the total X_L in series and parallel circuits. (E 5.3.7)
6. Discuss why X_L applies only to sine waves. (E 5.3.8)
7. Discuss the phase relationships between the current through an inductor and the voltage drop across the inductor. (E 5.3.9)
8. Have the students verify experimentally that $L_T=L_1+L_2$ when they are connected in parallel when no mutual coupling exists. (E 5.3.10)

SELECTED TOOLS AND MATERIALS

Power supply (variable voltate-regulated D.C. source)
Isolation transformer
Variable autotransformer
Oscilloscope
EVM
Resistor (½ W 10,000 Ohms; 5-W 500 Ohm)
Inductors (2 iron-core chokes, 8 H at 50 MAdc whose R=250 Ohms)
SPST and SPDT switches
Milliammeter (0-100 mAdc)

SELECTED AUDIOVISUAL MATERIALS

SELECTED REFERENCES

Basic Electronics. 5th Edition. Bernard Grob. (Chapter 18)

Basic Electricity: A Text-Lab Manual. Paul B. Zbar. (Experiment #43)

Introductory Circuit Analysis. 4th Edition. Robert L. Boylestad. (Chapter 15)

DUTY AREA

5. DEMONSTRATING A.C. KNOWLEDGE

PROGRAM

TASK/COMPETENCY

5.4 Calculate the phase angle in RL circuits

COURSE

5.4

PERFORMANCE OBJECTIVE

P 5.4 Given a schematic diagram, a series RL circuit, and a parallel RL circuit, calculate the phase angle and draw the phasor diagram for each; all calculations and phasor diagrams must be within ±1% of the instructor derived values.

SELECTED ENABLING OBJECTIVES

E 5.4.1 Explain why i_L lags v_L in a sine wave circuit and why the inductive current is the same in all parts of a series circuit.

E 5.4.2 Explain why the inductive voltage is the same across parallel branches.

E 5.4.3 Calculate the phase angle and draw the phasor diagram V_R and V_L in a series RL circuit.

E 5.4.4 Write the formula for Z(impedance) for a series RL circuit.

E 5.4.5 Draw a schematic circuit showing a resistor (R=10 ohm) and inductor (X_L=10 ohms) connected in parallel with a source voltage V_A=100V).

E 5.4.6 Draw the wave forms of applied voltage and branch currents in the phasor diagram of E 5.4.5.

E 5.4.7 Calculate the impedance (Z_T) and the phase angle of a parallel RL circuit.

E 5.4.8 Define Q of a coil and explain how it is effected by internal resistance of the coil.

E 5.4.9 Define:

A. Skin effect,
B. A.C. effective resistance,
C. A.F. choke,
D. R.F. choke, and
E. The time constant of an inductive circuit.

CRITERION-REFERENCED MEASURE

C 5.4 Calculate the phase angle and draw the phasor diagram for a series RL circuit and a parallel RL circuit; all calculations and phasor diagrams must be within ±1% of instructor derived values.

SELECTED INSTRUCTIONAL ACTIVITIES

1. Discuss the relationship between i_L and v_L in an inductive series circuit. (E 5.4.1 and E 5.4.3)

2. Discuss the relationship between i_L and v_L in an inductive parallel circuit. (E 5.4.2, E 5.4.5, and E 5.4.6)

3. Discuss impedance in a series RL circuit and methods used to calculate the total impedance. (E 5.4.4)

4. Discuss the impedance in a parallel RL circuit and the methods used to calculate the total impedance. (E 5.4.6 through E 5.4.8)

5. Discuss the meaning of the Q of a coil. (E 5.4.8)

6. Discuss the following:

   A. Skin effect,
   B. AC effective resistance,
   C. A.F. and R.F. chokes, and
   D. Time constaints in inductive circuits. (E 5.4.9)

SELECTED TOOLS AND MATERIALS

SELECTED AUDIOVISUAL MATERIALS

SELECTED REFERENCES

Basic Electronics. 5th Edition. Bernard Grob. (Chapter 19)

Introductory Circuit Analysis. 4th Edition. Robert L. Boylestad. (Chapter 15)

IEEE Standard Dictionary of Electrical and Electronic Terms. John Wiley.

DUTY AREA

5. DEMONSTRATING A.C. KNOWLEDGE

PROGRAM

TASK/COMPETENCY

5.5 Calculate total capacitance

COURSE

5.5

PERFORMANCE OBJECTIVE

P 5.5 Given schematic diagrams of several capacitors connected in a series circuit and connected in a parallel circuit, calculate the total capacitance in each circuit; all calculated values must be within ±1% of instructor calculated values.

SELECTED ENABLING OBJECTIVES

E 5.5.1 Define capacitance and explain how a charge is stored in the dielectic.

E 5.5.2 Explain what is meant by a dielectic material and name five common dielectic materials.

E 5.5.3 Explain how to charge and discharge a capacitor.

E 5.5.4 Define one farad of capacitance.

E 5.5.5 Define dielectic constant and dielectric strength.

E 5.5.6 State the formula used to calculate the value of capacitance using its physical factors.

E 5.5.7 Draw the schematic symbols for the following types of capacitors:

A. Fixed,
B. Electrolytic,
C. Variable
D. Ganged, and
E. One shaft.

E 5.5.8 Calculate the charge stored in a 2 uf capacitor with 50V across it.

E 5.5.9 Explain the temperature coefficient of a ceramic capacitor and how it is used for temperature compensation.

E 5.5.10 Explain capacitive tolerance and how it varies for different types of capicators.

E 5.5.11 Explain the meaning of the voltage rating of capacitors.

E 5.5.12 Explain the precaution necessary in connecting an electrolytic capacitor in a circuit.

E 5.5.13 State the formulas used to calculate the total capacitance of capacitors cqnnected in series and in parallel.

E 5.5.14 Draw a schematic diagram showing the least number of 400V 2 u(MICRO)F capacitors needed for a combination rated at 800V with 2u (micro) total capacitance.

E 5.5.15 Define the following:

A. Stray circuit capacitance,
B. Distributed capacitance of a coil,
C. Leakage resistance of a capacitor, and
D. Power factor and Q of a capacitor.

E 5.5.16 Conduct an experiment to:

A. Find the capacitance value of a capacitor by means of the EIA color code,
B. Use capacitance checkers to determine capacitance, leakage, and power factors, and
C. Use an EVM for testing shorted or leaky capacitors.

CRITERION-REFERENCED MEASURE

C 5.5 Calculate the total capacitance in each circuit; all calculated values must be within ±1% of instructor calculated values.

SELECTED INSTRUCTIONAL ACTIVITIES

1. Discuss capacitors in terms of:
    - A. Their physical construction;
    - B. How they store a charge in the dielectric;
    - C. Their units of measure; and
    - D. The different types. (E 5.5.1 through E 5.5.5)
2. Demonstrate, by using the formula, how the value of a capacitor varies as the dielectric constant, area of the parallel plates, and the distance between the plates varies. (E 5.5.6)
3. Explain the different schematic symbols used for the different types of capacitors. (E 5.5.7)
4. Explain the formula used to calculate the charge stored in a capacitor. (E 5.5.8)
5. Discuss the temperature coefficient of a ceramic capacitor and how it is identified. (E 5.5.9)
6. Discuss the EIA capacitor color code and how it is used. (E 5.5.10)
7. Discuss electroyltic capacitors, their use and the precaution that must be observed when connecting them in a circuit. (E 5.5.11, E 5.5.12, and E 5.5.140
8. Demonstrate how to calculate the total capacitance of a capacitor connected in series and in parallel. (E 5.5.13 and E 5.5.14)
9. Discuss stray capacitance, leakage resistance, power factor and Q of a capacitor. (E 5.5.15)
10. Demonstrate the use of a capacitance checker. (E 5.5.10)
11. Have the students conduct an experiment to:
    - A. Find the capacitance value of a capacitor by means of the EIA color code;
    - B. Use a capacitance checker to determine capacitance, leakage, and power factor; and
    - C. Use an EVM for testing shorted or leaky capacitors. (E 5.5.16)

SELECTED TOOLS AND MATERIALS

Power supply (variable D.C. voltage supply)
EVM
Capacitance checker
Capacitors (assortment of paper, mica, ceramic, and electrolytic, including 0.01uF, 0.01uF, and 0.5uF)

SELECTED AUDIOVISUAL MATERIALS

SELECTED REFERENCES

Basic Electronics. 5th Edition. Bernard Grob. (Chapter 20)

Basic Electricity: Text Lab Manual. 5th Edition. Paul B. Zbar. (Experiment #45)

Introductory Circuit Analysis. 4th Edition. Robert L. Boylestad. (Chapter 9)

DUTY AREA

5. DEMONSTRATING A.C. KNOWLEDGE

PROGRAM

TASK/COMPETENCY

5.6 Calculate capacitive reactance

COURSE

5.6

PERFORMANCE OBJECTIVE

P 5.6 Given several values of capacitance, calculate the value of the capacitive reactance for each, when a sine wave of 1000Hz is applied across each; all calculated values must agree within ±1% of the instructor-calculated values.

SELECTED ENABLING OBJECTIVES

E 5.6.1 Explain how A.C. current flows in a capacitive circuit.

E 5.6.2 Define capacitive reactance and state its unit of measure.

E 5.6.3 Explain how X_c (capacitive reactance) reduced the amount of current in an AC circuit.

E 5.6.4 State the formula used to calculate X_c and explain how X_c varies as C and F varies.

E 5.6.5 Calculate the value of X_c for several different values of capacitance.

E 5.6.6 Write the formula used to calculate the total X_c for capacitors connected in series and connected in parallel.

E 5.6.7 Write the formula used to calculate the instanteous value of charging current i_c.

E 5.6.8 State two differences and one similarity between X_L and X_C.

E 5.6.9 Explain why the current i_c leads the voltage v_c in a capacitive circuit.

E 5.6.10 Conduct an experiment to verify experimentally that the capacitive reactance X_c of a capacitor is given by the capacitive reactance formula.

E 5.6.11 Conduct an experiment to:

A. Measure the phase angle between voltage and current in a capacitive circuit using a dual-trace oscilloscope.

B. Measure the phase angle between voltage and current in a capacitive circuit directly by using a single-trace oscilloscope.

CRITERION-REFERENCED MEASURE

C 5.6 Calculate the value of the capacitive reactance when a sine wave of 1000Hz is applied across each; all calculated values must agree within ±1% of the instructor calculated values.

SELECTED INSTRUCTIONAL ACTIVITIES

1. Explain capacitive reactance X_C and its effects on A.C. current. (E 5.6.1 through E 5.6.3)
2. Explain the formula used to calculate X_C and demonstrate its use. (E 5.6.4 and E 5.6.5)
3. Discuss X_C in series and parallel circuits and explain how Ohms law still applies by comparing X_C with R. (E 5.6.6 and E 5.6.8)
4. Discuss how the current i_C leads the voltage v_C in a capacitive circuit and demonstrate the formula used to calculate the instantaneous value of the charging current i_C. (E 5.6.7 and E 5.6.9)
5. Review/demonstrate the operations of a single-trace and dual-trace triggered sweeep oscilloscope. (E 5.6.11)
6. Have the students conduct an experiment to prove experimentally the capacitive reactance formula. (E 5.6.10)
7. Have the students conduct an experiment to:
    A. Measure the phase angle between voltage and current in a capacitve circuit using a dual-trace oscilloscope. (E 5.6.10 and E 5.6.11)

    B. Measure the phase angle between voltage and current directly by using a single-trace oscilloscope.

SELECTED TOOLS AND MATERIALS

Power supply
Isolation transformer
Variable autotransformer
EVM
Oscilloscope (0-5 MAdc milliammeter)
Capacitance tester
Resistor (½-W, 5600 Ohms)
Capacitors (0.5 uF, o.1 uF)

SELECTED AUDIOVISUAL MATERIALS

SELECTED REFERENCES

Basic Electronics. 5th Edition. Bernard Grob. (Chapter 21)

Basic Electricity: Text Lab Manual. 5th Edition. Paul B. Zbar. (Experiment #47 and 48)

Introductory Circuit Analysis. 4th Edition. Robert L. Boylestad. (Chapter 9)

DUTY AREA

5. DEMONSTRATING A.C. KNOWLEDGE

PROGRAM

TASK/COMPETENCY

5.7 Calculate circuit parameters for an RC circuit

COURSE

5.7

PERFORMANCE OBJECTIVE

P 5.7 Given a series RC circuit and a parallel RC circuit, calculate the following circuit parameters for: (a) branch current (parallel only), (b) total circuit current, (c) total impedance, (d) the phase angle of the circuit, and compare the phase angle of the voltage across R and X_C; all calculated values must be within ±1% of instructor-calculated values.

SELECTED ENABLING OBJECTIVES

E 5.7.1 Describe the phase relationship between v_c and i_c in a capacitive circuit with a sine wave of voltage applied.

E 5.7.2 Explain how a capacitor charges when the applied voltage is increased.

E 5.7.3 With a sine wave of voltage is applied across a capacitor:

A. Draw the schematic diagram;
B. Draw the sine wave of voltage and current out of phase by 90°; and
C. Draw a reactor diagram showing the phase angle of -90° between V and I.

E 5.7.4 Explain why a circuit with R and X_C in series will be less capactive as the frequency of the applied voltage is increased.

E 5.7.5 Define the following:

A. Coupling,
B. Capacitor,
C. Sawtooth voltage, and
D. Capacitive voltage divider.

E 5.7.6 Work several series RC circuit problems applying phasor addition of V_C and V_R, X_C and R to find V_T and Z_T and the phase angle.

E 5.7.7 Work several parallel RC circuit problems applying phasor addition of I_R and I_C to find I_T, Z_T and phase angle.

E 5.7.8 Explain capacitive voltage divers and write the general equation.

E 5.7.9 Explain how a coupling capacitor is chosen for a circuit.

E 5.7.10 Write the formula for the general case of capacitive current i_c.

E 5.7.11 Verify experimentally and prove analystically that the voltage V_1 across a capacitor C_1 in a series-connected capacitve voltage divider is given by the formula $V_1=V(C_T/C_1)$.

E 5.7.12 Verify experimentally that the impedance Z of a series RC circuit is given by the equation for the phasor sum of X_C and R.

CRITERION-REFERENCED MEASURE

C 5.7 Calculate the following circuit paramaters: (a) branch current (parallel only), (b) total circuit current, (c) total impedance, (d) the phase angle of the circuit, and compare the phase angle of the voltage across R and X_C; all calculated values must be within ±1% of instructor calculated values.

SELECTED INSTRUCTIONAL ACTIVITIES

1. Discuss the charge and discharge current in a capacitor with a sine wave of voltage applied. (E 5.7.1 through E 5.7.3).
2. Demonstrate graphically and with phasor diagrams the phase relationships between v_c and i_c. (E 5.7.1 through E 5.7.3)
3. Discuss phasor diagrams, how they are drawn and how they are used to calculate circuit parameters in RC circuits. (E 5.7.4, E 5.7.6, and E 5.7.7)
4. Demonstrate, using phasor addition, the solution to several series RC circuits. (E 5.7.6)
5. Have the students solve several series RC circuit problems. (E 5.7.6)
6. Discuss coupling capacitors, capacitive voltage dividers, and saw tooth voltage. (E 5.7.5, E 5.7.8, and E 5.7.9)
7. Explain why the capacitive charge and discharge current i_c is always equal to $C(d_v/d_t)$. (E 5.7.10)
8. Have the students conduct an experiment to verify experimentally and prove analytically that the voltage V_1 across a capacitor C_1 series circuit-connected capacitive voltage divider is given by the formula $V_1=(VC_T/C_1)$. (E 5.7.11)
9. Have the students conduct an experiment to verify experimentally that the impedance Z of a series RC circuit is given by the equation for phasor addition of X_c and R.

SELECTED TOOLS AND MATERIALS

Power supply (isolated 6.3V RMS 18-V peak-to-peak)
AC source
Capacitance tester
Electronic voltmeter
Capacitors (0.5uF, two 0.1uF, 0.05uF)

SELECTED AUDIOVISUAL MATERIALS

SELECTED REFERENCES

Basic Electronics. 5th Edition. Bernard Grob. (Chapter 22)

Basic Electricity: Text Lab Manual. 5th Edition. Paul B. Zbar. (Experiment #50)

Introductory Circuit Analysis. 4th Edition. Robert L. Boylestad. (Chapter 15)

DUTY AREA

5. DEMONSTRATING A.C. KNOWLEDGE

PROGRAM

TASK/COMPETENCY

5.8 Calculate RC and RL time constant

COURSE

5.8

PERFORMANCE OBJECTIVE

P 5.8 Given a D.C. power source and the value of the components in a series RL circuit and a series RC circuit, calculate the time constant for each; all calculated values must be within ±1% of the instructor calculated values.

SELECTED ENABLING OBJECTIVES

E 5.8.1 State Lenz' law and explain how it applies to counter electro motive force (CMF).

E 5.8.2 Define transient response.

E 5.8.3 Define time constant.

E 5.8.4 Explain why L/R equals time, using the formula $V=L(di/dt)$ in your proof.

E 5.8.5 Draw the graph for I during five time constant for a series RL circuit; shade in the area representing one time constant.

E 5.8.6 Explain how to calculate the peak value V_L in a series RL circuit.

E 5.8.7 Explain how high voltage is produced by opening the switch in a series RL circuit.

E 5.8.8 Explain why transient response in a capacitive circuit is measured in terms of the product RC, using the formula $Q=CV$ in your proof.

E 5.8.9 Draw the graph for V during five time constant for a series RC circuit; shade in the area representing one time constant.

E 5.8.10 Explain why the time constant in an RC circuit indicates the rate of charge or discharge of the capacitor.

E 5.8.11 State the formula for the energy stored in electric field of a capacitor and its unit of measure.

E 5.8.12 Explain how capacitance opposes a voltage change across itself.

E 5.8.13 Explain which produces more i_c, a faster dv/dt or a slower dv/dt.

E 5.8.14 Define the following:
- A. A long RC time constant,
- B. A short RC time constant,
- C. A RC differentiating circuit, and
- D. A RC integrating circuit.

E 5.8.15 Calculate the time required for a 0.05 uFC to discharge to a V_c equal to 132V after it has been charged to 264V and discharged through a 40K Ohm R.

E 5.8.16 Conduct an experiment to determine expermentally the time it takes a capacitor to charge through a resistor and how long it takes a capacitor to discharge through a resistor.

CRITERION-REFERENCED MEASURE

C 5.8 Calculate the time constraint of a series RL circuit and a series RC circuit; all calculated values must be within ±1% of the instructor calculated values.

SELECTED INSTRUCTIONAL ACTIVITIES

1. Review Lenz' law and counter EMF. (E 5.8.1)
2. Explain transient response, time constant, and how they are related in RL circuits. (E 5.8.2 and E 5.8.3)
3. Demonstrate how the formula $V=L(di/dt)$ is used to calculate the voltage induced in an inductor. (E 5.8.4, E 5.8.6, and E 5.8.7).
4. Demonstrate how graphs are used in plotting RL time constants. (E 5.8.5)
5. Demonstrate how the formula $Q=CV$ may be used to explain why the produced RC has time as its unit of measure. (E 5.8.8).
6. Demonstrate how to construct a graph for V during five (5) time constants in a series RC circuit. (E 5.8.9)
7. Explain the rate of charge and discharge of a capacitor and how the capacitance opposes a change in voltage across it. (E 5.8.10 and E 5.8.11)
8. Demonstrate how the energy stored in the dielectric of a capacitor may be calculated. (E 5.8.12)
9. Discuss dv/dt and how it relates to i_c. (E 5.8.13)
10. Discuss the following and give several examples of each:
    A. Long RC time constant,
    B. Short RC time constant,
    C. Differentiating circuits, and
    D. Integrating circuit. (5.8.14)
11. Discuss the formula used to calculate the decay of the voltage v_c across a capacitor in an RC circuit, and demonstrate several examples of its use in calculating v_c at anytime or t at any value of v_c. (E 5.8.15)
12. Have the students determine experimentally the time it takes a capacitor to charge through a resistor and discharge through a resistor. (E 5.8.16)

SELECTED TOOLS AND MATERIALS

Power supply (regulated variable direct current)
EVM
Square-wave generator
Oscilloscope
Resistors (½ watt, 1M ohm, 10,000 ohm)
Capacitor (1 micro F, 0.005 micro F)
Two SPST switches, watch with a second hand
Watch with a second hand

SELECTED AUDIOVISUAL MATERIALS

"Universal Time Constant Chart for RC and RL Circuits" (wall chart)

SELECTED REFERENCES

Basic Electronics. 5th Edition. Grob. (Chapter 23)

Basic Electricity: Text Lab Manual. 5th Editiion. Paul B. Zbar. (Experiment #46)

Introductory Circuit Analysis. 4th Edition. Robert L. Boylestad.

DUTY AREA

5. DEMONSTRATING A.C. KNOWLEDGE

PROGRAM

TASK/COMPETENCY

5.9 Calculate impedance of RLC circuits

COURSE

5.9

PERFORMANCE OBJECTIVE

P 5.9 Given a series RLC circuit and a parallel RLC circuit, calculate the circuit impedance of each; all calculated values must be within ±1% of the instructor-calculated value.

SELECTED ENABLING OBJECTIVES

E 5.9.1 Explain why series or parallel resistance can be combined in A.C. circuits the same way as in D.C. circuits.

E 5.9.2 Explain why X_L and X_C reactance in series cancel each other and with X_L and X_C reactance in parallel their branch currents cancel.

E 5.9.3 Give one difference in electrical characteristics comparing R and X_C, R and Z, X_C and C, X_L and L.

E 5.9.4 Draw a phasor diagram for a series RLC circuit showing the phase of the voltage drops IR, IX_C, and IX_L with respect to the reference phase of the common current I.

E 5.9.5 Explain briefly why the two opposite phasors at +90° for X_L and -90° for I_L both follow the principle that any self-induced voltage leads the current thorugh the coil by 90°.

E 5.9.6 Explain why a reactance phasor is always at exactly 90°, but an impedance phasor can be less than 90°.

E 5.9.7 Explain why the impedance of a series circuit must be more than either its X or R value.

E 5.9.8 Explain why I_T in a parallel circuit must be more than either its I_R or I_x value.

E 5.9.9 Define:

A. Real power,
B. Apparent power, and
C. Power factor.

E 5.9.10 Explain why the power factor should be as close to unity as possible.

E 5.9.11 Explain how to correct for a lagging inductive component of a current in the main power line.

E 5.9.12 Determine experimentally the effects on impedance and current as the frequency of the A.C. source changes in a series RLC circuit.

CRITERION-REFERENCED MEASURE

C 5.9 Calculate the circuit impedance in a series RLC circuit and a parallel RLC circuit; all calculated values must be within ±1% of instructor calculated values.

SELECTED INSTRUCTIONAL ACTIVITIES

1. Discuss the effects of resistance on both A.C. and D.C. current. (E 5.9.1)
2. Discuss X_L and X_C in series and parallel circuits (E 5.9.2)
3. Explain phasor addition of reactances and currents. (E 5.9.2)
4. Discuss the electrical characteristics of R_1, X_C, X_L, and Z. (E 5.9.3)
5. Discuss phasor diagrams and how they are used to show the relationship between voltage drops across X, R and C. (E 5.9.4)
6. Demonstrate using phasors for X_L and I_L that both follow the principle that any self-induced voltage leads the current through the coil by 90°. (E 5.9.5)
7. Demonstrate, using phasor diagrams, the relationship between reactance, impedance, and current in both series and parallel circuits. (E 5.9.6 though E 5.9.8)
8. Discuss real power, apparent power, and power factor and explain why the power factor should be as close to unity as possible and how to correct for a lagging power factor.
9. Have the students conduct an expriment to determine the changes in frequency of an AC source on Z and I in a series RC circuit. (E 5.9.12)

SELECTED TOOLS AND MATERIALS

SELECTED AUDIOVISUAL MATERIALS

SELECTED REFERENCES

Basic Electronics. 5th Edition. Bernard Grob. (Chapter 24)

Basic Electricity: Text Lab Manual. 5th Edition. Paul B. Zbar. (Experiment #60)

Introductory Circuit Analysis. 4th Edition. Robert L. Boylestad. (Chapter 15)

DUTY AREA

5. DEMONSTRATING A.C. KNOWLEDGE

PROGRAM

TASK/COMPETENCY

5.10 Apply complex numbers to A.C. circuit calculations

COURSE

5.10

PERFORMANCE OBJECTIVE

P 5.10 Given a series parallel circuit with the following: (a) the series impedance is 7+j9, (b) the parallel branches are 2+j2 and 4-j3, and (c) the applied voltage is 10 VOLTS, use complex numbers to calculate the total circuit impedance, total circuit current, and phase angle; all calculated values must be within ±1% of instructor-calculated values.

SELECTED ENABLING OBJECTIVES

E 5.10.1 Define the j operator.

E 5.10.2 Draw a graph for:
- A. j,
- B. -j, and
- C. j^2

E 5.10.3 Using the graph shown in E 5.10.2, state the angle for:
- A. j,
- B. -j,
- C. j^2, and
- D. j^3.

E 5.10.4 Define a complex number.

E 5.10.5 Write the formula for Z_t of a series circuit containing R, X_L, and X_C using complex numbers.

E 5.10.6 Write the formula for Z_t of a parallel circuit that has two (2) branches, where one (1) branch has an R in series with X_L and the other branch an R in series with X_C; the solution must use all complex numbers.

E 5.10.7 State the six (6) rules for operations with complex numbers.

E 5.10.8 Define the sine, cosine, and tangent function of an angle.

E 5.10.9 Work several problems converting polar to rectangular form.

E 5.10.10 Work several problems in series A.C. circuits using complex numbers to calculate Z_t in rectangular and polar form.

E 5.10.11 Work several problems in parallel A.C. circuits using complex numbers to calculate Z_t.

E 5.10.12 Compare the following combinations:
- A. Resistance R and conductance G,
- B. Reactance X and susceptance B, and
- C. Impedance Z and admittance Y.

E 5.10.13 Explain the sequence of calculations used to calculate the value Z_t for any three (3) complex impedances in parallel, by means of complex branch currents.

CRITERION-REFERENCED MEASURE

C 5.10 Use complex numbers to calculate the total circuit impedance, total circuit current, and phase angle; all calculated values must be within ±1% of instructor calculated values.

SELECTED INSTRUCTIONAL ACTIVITIES

1. Review negatives and positive numbers and explain the j operator. (E 5.10.1)
2. Discuss the relationship between the j operator and phase angle. (E 5.10.2 and E 5.10.3)
3. Discuss complex numbers and how they are used in the solution of A.C. series and parallel circuits. (E 5.10.5 and E 5.10.6)
4. Discuss the operations with complex numbers and demonstrate the six (6) rules of operations. (E 5.10.7)
5. Discuss the magnitude and angle of a complex number and explain the sine, cosine, and tangent of an angle. (E 5.10.8)
6. Demonstrate how to convert polar form to rectangular form, then assign several problems for the students to solve. (E 5.10.9)
7. Demonstrate how to calculate Z_t in series A.C. circuits using complex numbers, then assign problems for the students to solve. (E 5.10.10)
8. Demonstrate how to calculate Z in parallel A.C. circuits using complex numbers, then assign several problems for the students to solve. (E 5.10.11)
9. Discuss the following and explain when and where it is best to use one instead of the other:
    A. Resistance vs conductance,
    B. Reactance vs susceptance, and
    C. Impedance vs admittance. (E 5.10.12)
10. Demonstrate the solution of parallel circuits with three (3) complex branches using the method of branch currents.
11. Demonstrate the solution of series parallel A.C. circuits with complex impedance.

SELECTED TOOLS AND MATERIALS

SELECTED AUDIOVISUAL MATERIALS

SELECTED REFERENCES

Basic Electronics. 5th Edition. Bernard Grob. (Chapter 25)

Introductory Circuit Analysis. 4th Edition. Robert L. Boylestad. (Chapter 14)

DUTY AREA

5. DEMONSTRATING A.C. KNOWLEDGE

PROGRAM

TASK/COMPETENCY

5.11 Compute Kirchhoff's laws for network analysis of A.C. circuits

COURSE

5.11

PERFORMANCE OBJECTIVE

P 5.11 Given an A.C. circuit with four (4) A.C. voltages around a closed loop, three of them are V_{BA}=25V at 45°, V_{CB}=50V at -45°, and V_{DC}=100V, calculate, using Kirchhoff's laws, the fourth unknown voltage in polar form, in rectangular form, and state V in double-subscript notation, drawing the phasor diagram to approximate scale for the four (4) voltages; all calculated values and the phasor diagram must agree within ±1% of the instructor-calculated values.

SELECTED ENABLING OBJECTIVES

E 5.11.1 Explain the use of double-subscript notation in analyzing electronic circuits.

E 5.11.2 Explain Kirchhoff's voltage law for A.C. circuits and how it differs from from D.C.

E 5.11.3 Explain Kirchhoff's current law for A.C. circuits.

E 5.11.4 Explain what is meant by a closed path.

E 5.11.5 Desribe how phasors are added graphically.

E 5.11.6 Determine the unknown loop voltage in rectangular and polar form for a circuit that has five A.C. voltages in a closed loop; the known voltages are 300V at 80°, 100V at -65°, 180V at 225°, and 200V at 135°.

E 5.11.7 Calculate I_D with respect to point Y in polar form when three (3) currents are approaching point Y in a circuit; the three currents are I_a=25A at 40°, I_B=10A at 75°, and I_C=5A at 10°.

E 5.11.8 Convert (12+j6)V to polar form and state the voltage 180° out of phase in polar and rectangular form.

CRITERION-REFERENCED MEASURE

C 5.11 Calculate, using Kirchhoff's laws, the fourth unknown voltage in polar form, in rectangular form, and state V in double-subscript notation, drawing the phase diagram to approximate scale for the four (4) voltages; all calculated values and the phasor diagram must agree within ±1% of the instructor calculated values.

SELECTED INSTRUCTIONAL ACTIVITIES

1. Discuss double-subscript notations and their use in analyzing electronic circuits. (E 5.11.1)

2. Review Kirchhoff's voltage law for D.C. circuits and explain how its application in A.C. circuits differs from D.C. (E 5.11.2)

3. Discuss Kirchhoff's current law in A.C. circuits and explain the meaning of a closed path. (E 4.11.3 and E 5.11.4)

4. Demonstrate how phasors are added graphically. (E 5.11.5)

5. Demonstrate the analysis of A.C. networks containing several voltages connected in a closed loop using polar and rectangular form. (E 5.11.6)

6. Demonstrate the use of Kirchhoff's current laws for several currents approaching a common point. (E 5.11.7)

7. Demonstrate the method used to convert from rectangular to polar and from polar to rectangular. (E 5.11.8)

SELECTED TOOLS AND MATERIALS

SELECTED AUDIOVISUAL MATERIALS

SELECTED REFERENCES

Basic Electronics. 5th Edition. Bernard Grob. (Chapter 26)

Introductory Circuit Analysis. 4th Edition. Robert L. Boylestad. (Chapter 15)

DUTY AREA

5. DEMONSTRATING A.C. KNOWLEDGE

PROGRAM

TASK/COMPETENCY

5.12 Compute V Thevenin and I Norton
for network analysis of AC circuits

COURSE

5.12

PERFORMANCE OBJECTIVE

P 5.12 Given a series parallel A.C. circuit with complex impedance and a constant sine-wave energy source, computer V_{Th}, Z_{Th}, I_N, and Z_N; all calculations must be within ±1% of the instructor calculated values.

SELECTED ENABLING OBJECTIVES

E 5.12.1 State Thevenin's theorem for A.C. circuits.

E 5.12.2 State the advantage of using Thevenin's theorem in A.C. circuits.

E 5.12.3 Thevenize several A.C. circuits containing complex impedance.

E 5.12.4 State Norton's theorem for A.C. circuits.

E 5.12.5 Explain the difference between a Thevenin equivalent circuit and a Norton equivalent circuit.

E 5.12.6 Nortonize several A.C. circuits containing complex impedances.

E 5.12.7 State two (2) differences between a voltage source and a current source.

E 5.12.8 Convert a Thevenin equivalent circuit into a Norton equivalent circuit.

CRITERION-REFERENCED MEASURE

C 5.12 Compute V_{Th}, Z_{Th}, I_N, and Z_N in a series parallel A.C. circuit with complex impedance and a contstant sine-wave energy source; all calculations must be within ±1% of the instructor calculated values.

SELECTED INSTRUCTIONAL ACTIVITIES

1. Explain Thevenin's theorem for A.C. circuits and how it differs from D.C. circuits. (E 5.12.1)
2. Discuss the advantages of using Thevenin's theorem in A.C. network analysis. (E 5.12.2)
3. Demonstrate the Theveninzing of A.C. networks containing complex impedance and assign several problems to the students. (E 5.12.3)
4. Explain Norton's theorem for A.C. circuits. (E 5.12.4)
5. Discuss the difference and the similarities between a Thevenin equivalent circuit and a Norton equivalent circuit. (E 5.12.5)
6. Demonstrate how to Nortonize an A.C. circuit containing complex impedances and assign several problems to the students. (E 5.13.6)
7. Discuss the characteristics of voltage sources and current sources; and explain their differences. (E 5.12.7)
8. Demonstrate the method used to convert a Thevenin equivalent circuit into a Norton equivalent circuit. (E 5.12.8)

SELECTED TOOLS AND MATERIALS

SELECTED AUDIOVISUAL MATERIALS

SELECTED REFERENCES

Basic Electronics. 5th Edition. Bernard Grob. (Chapter 26)

Introductory Circuit Analysis. 4th Edition. Robert L. Boylestad. (Chapter 8)

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DUTY AREA

5. DEMONSTRATING A.C. KNOWLEDGE

PROGRAM

TASK/COMPETENCY

5.13 Analyze series and parallel resonant circuits

COURSE

5.13

PERFORMANCE OBJECTIVE

P 5.13 Given a series and a parallel RLC resonant circuit, the value of R, L, and C and the voltage source, analyze the series circuit by calculating the following: f_r, X_L, X_C, Z_tQ, bandwidth, V_C and V_L; analyze the parallel circuits by calculating f_r,X_L, X_C, Q bandwidth, main line current I_t, tank current, and Z_t; explain how each circuit will behave as the frequency increases above f_r and decreases below f_r; all calculated values must agree within ±1% of the instructor's values and the explanation must agree with the theory.

SELECTED ENABLING OBJECTIVES

E 5.13.1 Define resonance.

E 5.13.2 Explain why any LC circuit can be resonant.

E 5.13.3 State the formula used to calculate the resonant fequency.

E 5.13.4 State two (2) characteristics of a series resonant circuit.

E 5.13.5 State the Q formula for a LC series resonant circuit.

E 5.13.6 Explain why a series resonant will look capacitive below resonant and inductive above resonant.

E 5.13.7 Explain why the impedance is minimum at resonance in a series resonant circuit.

E 5.13.8 Explain why the voltage across C or L is maximum at resonance in a series resonant circuit.

E 5.13.9 List the main characteristics of a parallel resonant circuit.

E 5.13.10 Explain why a parallel resonant circuit is sometimes referred to as a tank circuit.

E 5.13.11 Define:

A. Flywheel effect, and
B. Ringing.

E 5.13.12 Explain how the resonant frequency varies as the value of L and C varies.

E 5.13.13 Define Q, (figure of merit) of a series resonant circuit.

CRITERION-REFERENCED MEASURE

C 5.13 Analyze the series circuit by calculating the following: f_r, X_L, X_C, Z_tQ, bandwidth, V_C and V_L; analyze the parallel circuits by calculating f_r,X_L, X_C, Q bandwidth, main line current I_t tank current, and Z_t; explain how each circuit will behave as the frequency increases above f_r and decreases below f_r; all calculated values must agree within ±1% of insturctors values and the explanation must agree with the theory.

SELECTED ENABLING OBJECTIVES continued

E 5.13.14 State the Q formula for the following LC circuits:

A. Series resonant,
B. Parallel resonant, with series resistance r_s in the inductive branch, and
C. Parallel resonant, with zero series resistance but shunt

E 5.13.15 Explain briefly why a parallel LC circuit is inductive but a series LC circuit is capacitive below f_r.

E 5.13.16 Explain why a low-resistance generator is good for a high Q in series resonance, while a high-resistance generator is needed for a high Q in parallel resonance.

E 5.13.17 Define bandwidth.

E 5.13.18 Explain the effects of Q on the bandwidth.

E 5.13.19 Draw the response curve for a series resonant circuit that is resonant at 2000KHz and has a Q of 100, and identify the total bandwidth delta f and three edge frequencies f_1 and f_2.

E 5.13.20 Explain what is meant by the half-power point.

E 5.13.21 Explain how manual tuning of an LC circuit can be done with a capacitor or a coil.

E 5.13.22 Explain why the line current is minimum and the tank current is maximum at resonant in a parallel resonant circuit.

E 5.13.23 Determine experimentally:

A. The resonant frequency F_R of a series resonant LC circuit;
B. The frequency response of a series resonant LC circuit;
C. The effects of circuit Q on the frequency response; and
D. The effects of circuit Q on bandwidth at the half-power point.

E 5.13.24 Determine experimentally:

A. The resonant frequency of a parallel RLC circuit;
B. The measure line current and impedance at the resonant frequency; and
C. The measure effects of variation in circuit frequency on the impedance of a parallel RLC circuit.

SELECTED INSTRUCTIONAL ACTIVITIES

1. Discuss resonance effects and explain how any combination of LC can be resonant. (E 5.13.1 and E 5.13.2)
2. Discuss the characteristics of series resonant ciruits. (E 5.13.4, E 5.13.6 through E 5.13.8)
3. Explain the formula used to calculate the resonant frequency. (E 5.13.3)
4. Explain the Q formula for an LC series resonant circuit and explain how Q effects the resonant circuit. (E 5.13.5 and E 5.13.8)
5. Discuss the characteristics of a parallel resonant circuit. (E 5.13.9)
6. Discuss the term tank circuit and explain how it got its name. (E 5.13.10)
7. Explain fly wheel effect and ringing in a tank circuit. (E 5.13.11)
8. Discuss how a change in the value of L and/or C will affect the resonant frequency. (E 5.13.12)
9. Discuss Q (figure of merit) and demonstrate how the Q formula applies to series and parallel resonant circuits. (E 5.13.13 and E 5.13.14)
10. Discuss the effect of changing the frequency of a series and parallel resonant circuit. (E 5.13.15)
11. Demonstrate the effects of changing the frequency of a series and parallel resonant circuit using the response curve and showing when each circuit is capacitive or inductive. (E 5.13.15)
12. Discuss when a low-resistive and a high resistive generator should be used. (E 5.13.16)
13. Discuss bandwidth and explain how Q effects bandwidth. (E 5.13.17 and E 5.13.18)
14. Demonstrate the use of a response curve to find f_1, f_2 total bandwidth delta f and half-power point. (E 5.13.19 and E 5.13.20)
15. Discuss manual tuning of an LC circuit and how this may be done by adjusting either L or C. (E 5.13.21)
16. Discuss the relationship between line current and tank current (internal circulating current) and Q for parallel resonant circuits. (E 5.13.22)
17. Have the students determine experimentally the effects of Q on frequency response and bandwidth of a series resonant circuit. (E 5.13.23)
18. Have the students determine experimentally the characteristics of parallel resonant circuits. (E 5.13.24)

SELECTED TOOLS AND MATERIALS

AF sine-wave generator
Oscilloscope
EVM
Capacitors (0.005uF, 0.01uF, 0.05uF)
Choke 30 mH
Resistors (.5W, 100 ohm 2ea, 10 ohm, 47 ohm, 33 ohm and 10K ohm)

SELECTED AUDIOVISUAL MATERIALS

SELECTED REFERENCES

Basic Electronics. 5th Edition. Bernard Grob. (Chapter 27)

Introductory Circuit Analysis: A Lab Text Manual. 5th Edition. Paul B. Zbar. (Experiment #63, 64, and 65)

Introductory Circuit Analysis. 4th Edition. Robert L. Boylestad. (Chapter 20)

DUTY AREA

5. DEMONSTRATING A.C. KNOWLEDGE

PROGRAM

TASK/COMPETENCY

5.14 Analyze filter circuits

COURSE

5.14

PERFORMANCE OBJECTIVE

P 5.14 Given a schematic drawing for a bandpass filter and the value of X_L, R, R_L, and f_s calculate Q_s and the cutoff frequency, also sketch the frequency characteristics indicating on the curve the change in the frequency with the load applied; all calculated values and the sketch must agree within ±1% of instructor-calculated value and sketch.

SELECTED ENABLING OBJECTIVES

E 5.14.1 Describe the function of an electrical filter.
E 5.14.2 State two (2) examples where the voltage has different frequency components.
E 5.14.3 Explain pulsating direct current and voltage, and the two (2) components of a pulsating D.C. voltage.
E 5.14.4 Measure the value of the two (2) components of a pulsating D.C. voltage.
E 5.14.5 State the function of:
- A. High-pass filters,
- B. Low-pass filters,
- C. Bandpass filters, and
- D. Bandstop filters.

E 5.14.6 Draw circuit diagrams of:
- A. T-type high-pass filters,
- B. T-type low pass filters,
- C. Pi-type low pass
- D. Balanced filters with a filer reactance in both sides of the line.

E 5.14.7 Explain the difference between an L-type bandpass and L-type bandstop filter.
E 5.14.8 Plot the response curves for:
- A. A low-pass filter cutting off at 20,000 Hz,
- B. A high-pass filter cutting off at 20 Hz,
- C. Bandpass for 20 to 20,000 Hz, and
- D. Bandpass for 450 to 460 KHz.

E 5.14.9 State the differences between a passive and active filter.
E 5.14.10 State the purpose and advantage of:
- A. A constant-K filter,
- B. An M-derived filter,
- C. A crystal filter.

E 5.14.11 List the types of filters used as interference filters.
E 5.14.12 Experimentally, determine the frequency response of a high-pass and low-pass filter.
E 5.14.13 State one similarity and one difference in comparing a coupling capacitor and bypass

CRITERION-REFERENCED MEASURE

C 5.13 Calculate Q_s and the cutoff frequency, also sketch the frequency characteristics indicating on the curve the change in the frequency with the load applied; all calculated values and the sketch must agree within ±1% of instructor calculated value and sketch.

SELECTED INSTRUCTIONAL ACTIVITIES

1. Discuss the function of electrical filters and explain how a voltage can have different frequencies. (E 5.14.1 and E 5.14.2)
2. Explain what is meant by "D.C. insertion" and how the A.C. and D.C. components of pulsating D.C. are considered separately. (E 5.14.3)
3. Demonstrate how to measure the D.C. and A.C. component of pulsating D.C. (E 5.14.4)
4. Discuss the purpose and function of:
   - A. High-pass,
   - B. Low-pass,
   - C. Bandpass, and
   - D. Bandstop filters. (E 5.14.5 and E 5.14.6)
5. Use charts or draw schematics of the various circuit configurations of a filter, i.e., inverted-L, Pi-type, and T-type. (E 5.14.5 and E 5.14.6)
6. Explain the function of L-type filters used on a bandpass and bandstop with emphasis on circuit configurations, band-stop in series with R_L, bandpass is shunted with R_L. (E 5.14.7)
7. Demonstrate how to develop and plot response curves for:
   - A. High-pass,
   - B. Low-pass,
   - C. Bandpass, and
   - D. Bandstop at specified frequencies. (E 5.14.8)
8. Explain what a passive and active filter is and how they differ in operation and components used in the circuit. (E 5.14.9)
9. Discuss special filters, such as, the constnat K filter, m-derived filter, crystal filter, and the interference filter; explain the purpose and advantage of each. (E 5.14.9 through E 5.14.11)
10. Demonstrate how to construct a high-pass and a low-pass filer. (E 5.14.12)
11. Have students complete an experiment to determine frequency response of high-pass and low-pass filters. (E 5.14.12)
12. Explain coupling and bypass capacitors. (E 5.14.13)

SELECTED TOOLS AND MATERIALS

AF sine-wave generator
EVM
Resistors (½-W, 10,000 Ohms)
Hook-up wire
Capacitor (0.1 uF)
8H choke
Needle nose pliers
Diagonal cutters

SELECTED AUDIOVISUAL MATERIALS

SELECTED REFERENCES

Basic Electronics. 5th Edition. Bernard Grob. (Chapter 27)

Basic Electricity: A Text-Lab Manual. Paul B. Zbar. (Experiment 6)

Introductory Circuit Analysis. 4th Edition. Robert L. Boylestad. (Chapter 20)

DUTY AREA

EXPLORING ELECTRICITY AND ELECTRONICS TECHNOLOGY

TASK/COMPETENCY SEQUENCE

6.1 Explore occupations related to electricity and electronics technology

6.2 Identify (establish) management systems

DUTY AREA

6. EXPLORING ELECTRICITY AND ELECTRONICS TECHNOLOGY

PROGRAM

TASK/COMPETENCY

6.1 Explore occupations related to electricity and electronics technology

COURSE

6.1

PERFORMANCE OBJECTIVE

P 6.1 Given resource materials on occupations related to electricity and electronics technology, investigate selected occupations and report on two or more occupations of interest; report must include probable duration of occupation, wages or salary to be expected, physical requirements, educational or skill requirements for job entry, and a brief description of job duties.

SELECTED ENABLING OBJECTIVES

E 6.1.1 Identify and list selected occupations related to electricity and electronics.

E 6.1.2 Demonstrate how to use the Dictionary of Occupational Titles and Occupational Outlook Handbook; explain how to determine worker relationship to data, people, and things, using the DOT occupational codes.

E 6.1.3 List charateristics of the following work modes: mechanical, social, investigative, conventional, creative, and persuasive, and discuss how these work modes apply to various careers or jobs related to electricity or electronics technology.

CRITERION-REFERENCED MEASURE

C 6.1 Investigate a number of occupations related to electricity and electronics technology and list the following characteristics for each occupation; probable duration of occupation, wages or salary to be expected, physical requirements, the educational and skill requirements for job entry, and a brief description of job duties.

SELECTED INSTRUCTIONAL ACTIVITIES

1. Have students list selected occupations related to electricity and electronics technology and identify major duties for each occupation; include career opportunities in the military. (E 6.1.1)

2. Demonstrate how to use the Dictionary of Occupational Titles and Occupational Outlook Handbook to locate career and job information; explain how to determine worker relationships to data, people, and things, using the DOT occupational codes, and discuss work modes and how they describe various occupations in the electricity and electronics technology field. (E 6.1.2 and E 6.1.3)

3. Have students list the qualifications and educational background necessary for selected occupations. (E 6.1.1)

4. Have students select two or more occupations for a written report; it is suggested that students use their written reports as an outline and report orally to the class the results of their research. (E 6.1.1-E 6.1.3)

5. Invite a career counselor to speak to the class on the career decision-making process. (E 6.1.1-E 6.1.3)

SELECTED TOOLS AND MATERIALS

Report-writing materials

SELECTED AUDIOVISUAL MATERIALS

"Careers in Electricity" (LX 105). Career Aids, Inc. (color-sound filmstrip)
"Careers in Electronics" (LX 106). Career Aids, Inc. (color-sound filmstrip)
"Careers in Industry" (#79912). Audiovisual Services, Virginia Department of Education. (film)
"Electronics - - The Future and You" (#11616). Audiovisual Services. (film)

SELECTED REFERENCES

Dictionary of Occupational Titles. U.S. Department of Labor.
Encyclopedia of Careers and Vocational Guidance, Vols. I and II, Revised.
Electricity, Chapter 7. Basic Industrial Arts Series. Wilbur R. Miller, et al.
Manufacturing: A Basic Text for Industrial Arts. James Fales, et.al.
Occupational Outlook Handbook. U.S. Department of Labor.
Local newspaper help-wanted ads
State employment agency occupational outlook materials

DUTY AREA

6. EXPLORING ELECTRICITY AND ELECTRONICS TECHNOLOGY

PROGRAM

TASK/COMPETENCY

6.2 Identify (establish) management systems

COURSE

6.2

PERFORMANCE OBJECTIVE

P 6.2 Given a lecture and handouts on management systems used in electricity/electronics-related industries, identify and establish personnel for at least six positions needed for class and laboratory personnel systems according to instructor's guidelines.

SELECTED ENABLING OBJECTIVES

E 6.2.1 Describe activities of personnel in electricity/electronics-related industries.

E 6.2.2 List titles of officers in the American Industrial Arts Student Association (AIASA) and Vocational Industrial Club of America (VICA).

E 6.2.3 Describe the purpose of class/laboratory personnel systems.

CRITERION-REFERENCED MEASURE

C 6.2 Identify and establish at list six titles of personnel needed for class and laboratory personnel system according to instructor's guidelines.

SELECTED INSTRUCTIONAL ACTIVITIES

1. Show film or slides which illustrate personnel in electricity/electronics industries. (E 6.2.1)

2. Show slide/tape series, "AIASA--A Classroom Experience." (E 6.2.3)

3. Hand out information on duties of organization leaders and industry managers. (E 6.2.2)

4. Assign readings to help students learn about work people do. (E 6.2.1)

5. Give quiz matching titles of personnel to activities performed in a personnel system. (E 6.2.1-E6.2.3)

SELECTED TOOLS AND MATERIALS

SELECTED AUDIOVISUAL MATERIALS

"Careers in Electricity" (LX 105). Career Aids, Inc. (color-sound filmstrip)
"Careers in Electronics" (LX 106). Career Aids, Inc. (color-sound filmstrip)
"Careers in Industry" (#79912). Audiovisual Services, Virginia Department of Education. (film)
"Modern Corporation" (#47112). Audiovisual Services. (film)
"AIASA--A Classroom Experience." National AIASA. (slides)
"The Big Corporation" (#08413). Audiovisual Services, Virginia Department of Education. (film)

SELECTED REFERENCES

Student Association Activities in Industrial Arts Instruction. Industrial Arts Education Service

VICA Advisor's Manual. Virginia VICA Assocition. Richmond, Virginia.

DUTY AREA

ORGANIZING SAFETY AND LABORATORY MANAGEMENT SYSTEMS

TASK/COMPETENCY SEQUENCE

7.1 Identify safety rules and use lab equipment and machines safely

7.2 Participate in an organized personnel system to manage class and laborafory activities

DUTY AREA

7. ORGANIZING SAFETY AND
LABORATORY MANAGEMENT SYSTEMS

PROGRAM

TASK/COMPETENCY

7.1 Identify safety rules and use lab equipment and machines safely

COURSE

7.1

PERFORMANCE OBJECTIVE

P 7.1 Given electrical and electronic lab equipment and the proper safety instructions on each piece of equipment, list and explain general lab safety rules to the instructor's satisfaction; use the equipment and machines as directed by the instructor, in accordance with the Occupational Safety and Health Act (OSHA) accepted industrial safety standards.

SELECTED ENABLING OBJECTIVES

E 7.1.1 Identify the general safety rules and safety equipment.

E 7.1.2 Identify specific safety rules and equipment as they apply to use of each piece of equipment or machine.

E 7.1.3 Demonstrate the use of safety equipment as it applies to each piece of equipment or machine.

E 7.1.4 Explain the procedure used to extinguish an electrical fire.

E 7.1.5 List guidelines for maintaining a clean and orderly shop.

CRITERION-REFERENCED MEASURE

C 7.1 List and explain general lab safety rules to the instructor's satisfaction; demonstrate safe use or operation of selected pieces of equipment and machines as directed by instructor, in accordance with OSHA and accepted industrial safety standards.

SELECTED INSTRUCTIONAL ACTIVITIES

1. Have students read resource materials on safety and identify the general safety rules and safety equipment required for a safe working environment. (E 7.1.1-E 7.1.5)

2. Give a demonstration and audiovisual display or present materials on safety rules and equipment as they apply to each piece of equipment or machine and to specific tasks. (E 7.1.2)

3. Make a list of the safety rules that pertain to the laboratory. (E 7.1.3)

4. Have students practice safety rules in the laboratory each day. (E 7.1.1-E 7.1.5)

5. Form a safety committee to invite speakers on safety from industry. (E 7.1.1-E 7.1.5)

6. Explain how fire extinguishers are color coded and demonstrate how to put out a class C (electrical) fire. (E 7.1.4)

7. Explain how dirt and disorder create safety hazards and list guidelines for maintaining a clean and orderly lab or shop. (E 7.1.5)

SELECTED TOOLS AND MATERIALS

Safety posters
Shop equipment and machines

SELECTED AUDIOVISUAL MATERIALS

"Electrical Safety in the Shop." RMI Media Productions. (filmstrips/slide set/videotape)
"Industrial Arts Skill and Safety Series." Abraxas Films. (films)

SELECTED REFERENCES

Chapters on safety in course textbooks
Equipment safety manuals

DUTY AREA

7. ORGANIZING SAFETY AND
LABORATORY MANAGEMENT SYSTEMS

PROGRAM

TASK/COMPETENCY

7.2 Participate in an organized personnel system to manage class and laboratory activities

COURSE

7.2

PERFORMANCE OBJECTIVE

P 7.2 Given the list of in-class officers, committees, and the duties of each, participate in an organized personnel system for the class so that classroom and laboratory activities are managed in accordance with the instructor's guidelines.

SELECTED ENABLING OBJECTIVES

E 7.2.1 Discuss the need for people to have organizations.

E 7.2.2 List names of organizations in school, community, and industry.

E 7.2.3 Describe duties of officers and committees for the class.

E 7.2.4 Apply for a position in the personnel system and on a committee such as the "Safety Committee."

E 7.2.5 Follow in-class agenda to conduct meetings.

E 7.2.6 Manage classroom and laboratory activities with teacher.

CRITERION-REFERENCED MEASURE

C 7.2 Participate in the class personnel system as an officer or member of a committee so that classroom and laboratory activities are managed in accordance with the instructor's guidelines.

SELECTED INSTRUCTIONAL ACTIVITIES

1. Introduce students to the AIASA/VICA organization(s) through literature and slides. (E 7.2.1)
2. Present lessons on organizing personnel systems from AIASA/VICA Guides. (E 7.2.2)
3. Hand out and discuss a listing of the duties of officers and committees in personnel systems. (E 7.2.3 and E 7.2.4)
4. Show a film or filmstrip on meeting procedures. (E 7.2.5)
5. Explain organizational charts in which each leader and committee are identified. (E 7.2.3 and E 7.2.4)
6. Use the class safety committee to emphasize safety in the laboratory. (E 7.2.6)

SELECTED TOOLS AND MATERIALS

Flag and banner
Gavel
Officer symbols

SELECTED AUDIOVISUAL MATERIALS

"How to Conduct a Meeting." Audiovisual Services, Virginia Department of Education. (film)
"In-Class AIASA Management." Industrial Arts Education Service. (TV tape)
"Move with Tomorrow." Industrial Arts Education Service. (slides)
"Organizaing the Industrial Arts Student Association." Industrial Arts Education Service. (slides)

SELECTED REFERENCES

Organizing the Industrial Arts Student Association, Guide 1. Virginia Department of Education.

Robert's Rules of Order. Henry M. Roberts.

Student Association Activities in Industrial Arts, Guide 2. Virginia Department of Education.

VICA Advisor's Guide. Richmond, Virginia.

DUTY AREA

INTEGRATING THE STUDENT ORGANIZATION THROUGHOUT THE COURSE

TASK/COMPETENCY SEQUENCE

8.1 Participate in AIASA/VICA classroom activities

8.2 Investigate community (industrial) and technical resources

8.3 Participate in school (or community) improvement activities

DUTY AREA

8. INTEGRATING THE STUDENT ORGANZATION THROUGHOUT THE COURSE

PROGRAM

TASK/COMPETENCY

8.1 Participate in AIASA/VICA classroom activities

COURSE

8.1

PERFORMANCE OBJECTIVE

P 8.1 Given resources, teacher guidance, and the opportunity, participate in AIASA/VICA classroom activities in accordance with instructor guidelines.

SELECTED ENABLING OBJECTIVES

E 8.1.1 Identify and discuss goals of AIASA/VICA.

E 8.1.2 Participate in classroom elections for AIASA/VICA officers; define and discuss duties of class president, secretary, treasurer, reporter, sergeant-at-arms, parliamentarian, and historian.

E 8.1.3 Participate as an officer or voting member in democratic classroom decision-making activities.

CRITERION-REFERENCED MEASURE

C 8.1 Participate in AIASA/VICA classroom activities in accordance with instructor guidelines.

SELECTED INSTRUCTIONAL ACTIVITIES

1. List and discuss the goals of AIASA/VICA; provide students with background on the local, state, and national organizations. (E 8.1.1)

2. Have students organize the class for association activities; supervise the election of officers and discuss duties of the offices and membership. (E 8.1.2)

3. Review parliamentary procedure as necessary and serve in an advisory capacity during group meetings. (E 8.1.3)

4. Display association seal, motto, and goals on the classroom bulletin board. (E 8.1.1)

SELECTED TOOLS AND MATERIALS

Officer symbols
Banner
Notebooks

SELECTED AUDIOVISUAL MATERIALS

"AIASA - - A Classroom Experience." National AIASA (slides)
"Art of Communication: How to Conduct a Meeting (#21908). Audiovisual Servies, Virginia Department of Education (film)
"In-Class AIASA Management." Industrial Arts Education Service, Virginia Department of Education (film)
"Move With Tomorrow." Industrial Arts Education Service, Virginia Department of Education (film)
"Electornics - - The Future and You" (#11616). Audiovisual Services, Virginia Department of Education (film)

SELECTED REFERENCES

Student Association Activities in Industrial Arts Instruction. Industrial Arts Education Service.

VICA Advisor's Guide. Richmond, Virginia.

DUTY AREA

8. INTEGRATING THE STUDENT ORGANIZATION THROUGHOUT THE COURSE

PROGRAM

TASK/COMPETENCY

8.2 Investigate community (industrial) and technical resources

COURSE

8.2

PERFORMANCE OBJECTIVE

P 8.2 Given resources and an opportunity to participate in AIASA/VICA classroom activities, participate in a class-planned activity to investigate community and technical resources in accordance with student organization guidelines.

SELECTED ENABLING OBJECTIVES

E 8.2.1 Serve on a committee to identify and discuss possible community and technical resources to investigate.

E 8.2.2 List and discuss factors involved in successful planning for a field trip or guest speaker.

E 8.2.3 Participate in committee or class activities to select a possible classroom speaker or to plan a class field trip.

E 8.2.4 Prepare safety posters for local electricity/electronics-related industries.

CRITERION-REFERENCED MEASURE

C 8.2 Participate in a class-planned activity to investigate community and technical resources in accordance with student organization guidelines.

SELECTED INSTRUCTIONAL ACTIVITIES

1. Assist students and class committees in identifying possible community and technical resources to investigate as a student organization project. (E 8.2.1)

2. Discuss factors involved in successful planning for a field trip or guest speaker. (E 8.2.2)

3. Have students invite speakers from industry to speak on topics of interest or to give special demonstrations; involve students in selecting and planning field trips. (E 8.2.3)

4. Offer students credit for safety posters they make for local electricity/electronics industry. (E 8.2.4)

SELECTED TOOLS AND MATERIALS

Directories listing local industries

SELECTED AUDIOVISUAL MATERIALS

SELECTED REFERENCES

Student Association Activities in Industrial Arts Instruction. Industrial Arts Education Service

VICA Advisor's Guide. Richmond, Virginia.

DUTY AREA

8. INTEGRATING THE STUDENT ORGANIZATION THROUGHOUT THE COURSE

PROGRAM

TASK/COMPETENCY

8.3 Participate in school (or community) improvement activities

COURSE

8.3

PERFORMANCE OBJECTIVE

P 8.3 Given the resources and an opportunity to participate in AIASA/VICA classroom activities, participate in class-planned community or school improvement activity in accordance with student organization guidelines.

SELECTED ENABLING OBJECTIVES

E 8.3.1 List and discuss possible school or community improvement projects.

E 8.3.2 List and discuss factors to consider when planning and carrying out successful group projects.

E 8.3.3 Select a community or school improvement project, determine tasks to be done, and determine duties and responsibilities of class members; evaluate success of project upon completion.

CRITERION-REFERENCED MEASURE

C 8.3 Participate in a class-planned community or school improvement project in accordance with student organization guidelines.

SELECTED INSTRUCTIONAL ACTIVITIES

1. Help students identify possible school or community improvement projects. (E 8.3.1)
2. Discuss factors to consider when planning and carrying out successful group projects. (E 8.3.2)
3. Help students select, plan, implement, and evaluate a school or community improvement projects. (E 8.3.3)
4. Help students manage an electrical/electronic repair service for school personnel. (E 8.3.1-E 8.3.3)

SELECTED TOOLS AND MATERIALS

Directories listing local industries and social organizations in the community

SELECTED AUDIOVISUAL MATERIALS

SELECTED REFERENCES

Student Association Activities in Industrial Arts Instruction. Industrial Arts Education Service

SECTION III

PROGRAMS AND COURSES

The Electronics/Electromechanical courses described in this section are based on the task analysis presented in Section II of this guide. The program and courses are pending approval by the Virginia Department of Education, Division of Vocational and Adult Education. Presently, these courses are in a provisional status.

Course descriptions, content outlines, and suggested task teaching sequences for each course were developed using validated task analysis.

OVERVIEW OF THE MASTER TECHNICIAN PROGRAM

During the late seventies and the early eighties, the Commonwealth of Virginia has become the site of rapid development of new technology industries. These industries brought with them a need for technicians trained in the "new technology." Governor Charles Robb recognized this need and set out to adapt Virginia's educational system to meet the challenge. The interest of the Governor and of industry, joined by the Board of Vocational Education and the Community College Board, laid the basic foundation for the development of a program based on a new form of articulation. This articulated program, between secondary and postsecondary levels, makes each level responsible for two years of the total four years of training. This new program is called "2+2" by its creators.

Development of the program was based on four innovative concepts. First was the "2+2" concept itself. This refers to the articulation of a program of study between the secondary and postsecondary schools. Second, is the unique blending of academic and vocational education; through this defragmentation of the disciplines, students will gain a more significant understanding of the theory through application. Third, the program is designed to give maximum flexibility to students in selection of educational and career opportunities. This was done through curriculum design. Students who choose to leave the program before completion will not suffer loss of any Carnegie units. Lastly, various partnerships were formed to strengthen the program. There is the partnership between secondary and postsecondary institutions, the partnership between academic and vocational education programs, and the partnership between business/industry/government and education. Project participants refer to the collaborative efforts between business/industry/government and education as the BIG approach to curriculum development. It was through this approach that the DACUM (Develop a Curriculum) workshops were a success. Each of the BIG members gave first-line supervisors, middle managers, and production workers an opportunity to participate without loss of pay. It was these unique contributions of time and manpower that made the development of the Master Technician Program a reality.

The Master Technician Program is designed to satisfy the need for systems-oriented technicians. As such, it will:

- Prepare students for enrollment in advanced technical programs;
- Develop an understanding of industry and its place in society and the free enterprise system;

- Develop insights of the industrial processes and the practical application of scientific principles;
- Develop basic skills in the proper use of common industrial tools, materials, and processes; and
- Improve problem solving and creativity involving materials, processes, and products of industry.

Involvement in the VICA or AIASA organizations, which are co-curricular activities will provide students experiences with:

- An involvement with the community's industrial and technical resources;
- Activities to develop skills in parliamentary procedures and democratic decision making; and
- Recognition for exemplary performance, work skills, and safety procedures.

The following chart is a suggested sequence of offerings for the Master Technician Program:

SECONDARY CURRICULUM FRAMEWORK

TOTAL CURRICULUM

9th Grade	10th Grade	11th Grade	NEW HORIZONS TECHNICAL CENTER	12th Grade	NEW HORIZONS TECHNICAL CENTER
English	English	English	HS	English	HS
Health/PE	Health/PE	Materials/Processes of Industry	HS	Math or Science Elective	HS
Social Studies	Power & Transportation	American History	HS	Government	HS
Algebra I	Geometry	Algebra II	Electronics/ Electromechanical	Math or Science Elective	Electronics/ Electromechanical
Lab Science	Principles of Technology	*Electronics Elective	↓	*Electronics/ Elective	↓
Mechanical Drawing	↓	↓	↓	↓	↓

*If these courses are taught one period a day, it is suggested that students complete Electronics/ Electromechanical Technology II at the New Horizons Technical Center. Another alternative is to cover the required material in a three year program beginning at the 10th grade. This option eliminates the two electives.

Secondary Programs and Courses

Program Title: Vocational Technology Education

Description: These programs provide a foundation for career preparation and a sequence of opportunities to learn about the Industrial and Technological aspects of society. Instruction in these programs places emphasis upon the following:

a. Preparation of students for enrollment in advanced technical programs;
b. Development of an understanding of industry and its place in society and the free enterprise system;
c. Development of insights of the industrial processes and the practical application of scientific principles;
d. Development of basic skills in the proper use of common industrial tools, materials, and processes; and
e. Improvement of problem-solving materials, processes, and products of industry.

O. E. Code:

Suggested Grade Level: 11-12

Electronics/Electromechanical Technology I

Course Description: Electronics/Electromechanical Technology I requires 360 contact hours. It is a lecture/laboratory course for senior high school students preparing for the Master Technician Program. Students will perform circuit analysis on D.C. and A.C. circuits, develop and interpret schematic drawings, and fabricate a functional electronic unit.

Prerequisites: Algebra I and II

Suggested Grade Level: 11-12

Source: Master Technician Program (2+2)

Suggested Task/Competency Sequence

6.1 Explore occupations related to electricity and electronics technology.
6.2 Identify (establish) management systems.
7.1 Identify safety rules and use lab equipment and machines safely.
*7.2 Participate in an organized personnel system to manage class and laboratory activities.
*8.1 Participate in AIASA/VICA classroom activities.
*8.2 Investigage community industrial and technical resources.
*8.3 Participate in school (or community) improvement activities.
4.2 Interpret mechanical drawings.
1.1 Identify the parts of the atom.
4.1 Identify schematic symbols for electrical/electronic components.
4.4 Prepare an assembly layout.
1.2 Identify conductors, insulators, and semiconductors.
3.8 Construct a chassis.
1.3 Identify resistors.
1.4 Use Ohm's law formula.
1.5 Measure resistance, current, and voltage drop in a D.C. resistive circuit.
1.6 Analyze the relationship between R and I in a resistor.
1.7 Identify series circuit characteristics.
1.8 Identify parallel circuit characteristics.
1.9 Identify series-parallel circuit characteristics.
4.8 Prepare a wire routing sheet.
3.1 Demonstrate accepted soldering techniques.
3.2 Make wire wrap connections.
1.10 Analyze loaded and unloaded resistive voltage dividers.
3.3 Construct a wire harness (interface).
1.11 Analyze D.C. circuits using Kirchhoff's law.
1.12 Analyze D.C. circuits using the superposition theorem.
1.13 Use Thevenin's and Norton's theorems.

1.14 Use millman's theorem.
1.15 Analyze bridge circuits.
1.16 Identify types of batteries.
1.17 Demonstrate the law of magnetism.
1.18 Explain magnetic hysteresis.
1.19 Determine the magnetic polarity of a solenoid.
5.1 Define the characteristics of A.C.
5.2 Calculate current ratio.
5.3 Calculate inductive reactance.
5.4 Calculate the phase angle in R.L. circuits.
5.5 Calculate total capacitance.
5.6 Calculate capacitive reactance.
5.7 Calculate circuit parameters for an R.C. circuit.
4.6 Prepare pictorial drawings.
3.6 Install components on a P.C. board.
5.8 Calculate R.C. and R.L. time constants.
5.9 Calculate impedance of R.L.C. circuits.
5.10 Apply complex numbers to A.C. circuit calculations.
5.11 Compute Kirchhoff's laws for network analysis of A.C. circuits.
5.12 Compute V Thevenin and I Norton for network analysis of A.C. circuits.
5.13 Analyze series and parallel resonant circuits.
3.4 Prepare shielded wire and coaxial cables for installation.
5.14 Analyze filter circuits.

Electronics/Electromechanical Technology I

Outline and Code

Content Outline	Task/Competency Code
I. Orientation	
A. School and lab policies (safety)	7.1
B. Explore occupations related to electricity and electronics technology	6.1
1. Occupations related to electricity/electronics	E 6.1.1
2. Career information	E 6.1.2
3. Work modes	E 6.1.3
C. Management systems	6.2
D. Laboratory organization	7.2
E. Student organizations (AIASA/VICA)	8.1-8.3
II. Electrical Concepts (D.C.)	
A. Atomic structure	1.1
1. Use a periodic table	E 1.1.1
B. Molecular structure	1.2
1. Valence electrons	E 1.2.2
2. Molecular structure of conductors and semiconductors	E 1.2.3
C. Resistors	1.3
D. Voltage, current, and resistor relationships	1.4
1. The coulomb	E 1.4.1
2. D.C. current	E 1.4.2
3. D.C. voltage	E 1.4.3
4. Conventional and electron flow theories	E 1.4.5
5. Ohm's law	E 1.4.6
6. Energy and power	E 1.4.8
7. Power formula	E 1.4.9
E. Measurement of resistors, voltage, and current	1.5
1. Meter familiarization	E 1.5.1
2. Measure voltage and resistance	E 1.5.3
3. Resistor color code	E 1.5.3
4. Meter loading affects	E 1.5.8
F. Voltage and current relationship in a resistor	1.6
G. Kirchoff's Law	1.11
H. Superposition Theorem	1.12
I. Thevenin's and Norton's Theorems	1.13
J. Millman's Theorem	1.14
K. Electrical sources	1.14
1. Light, heat, piezo-effect, magnetism, chemical	E 1.4.4
L. Cells	1.16
1. Primary and secondary cells	E 1.16.1
2. Cells in series	E 1.16.3
3. Cells in parallel	E 1.16.4

III. Circuits	
A. Series circuits	1.7
B. Parallel circuits	1.8
C. Series-Parallel circuits	1.9
D. Voltage divider circuits	1.10
E. Bridge circuits	1.15
IV. Magnetism	
A. Laws of magnetism	1.17
B. Magnetic hystersis	1.18
C. Solenoid theory	1.19
V. Fabrication Techniques	
A. Soldering techniques	3.1
B. Wire wrap techniques	3.2
C. Wire harness construction	3.3
D. Shielded and Coaxial cable installation	3.4
E. Printed circuit boards	3.5
F. Component placement on P.C. boards	3.6
G. MOSFET handling techniques	3.7
H. Chassis construction	3.8
VI. Technical Communication Techniques	
A. Electrical/Electronic component symbols	4.1
B. Interpreting blueprints	4.2
C. Develop drawings	
1. Mechanical drawings	4.3
2. Assembly layout drawings	4.4
3. Electronic drawings	4.5
4. Pictorial drawings	4.6
D. Scales	4.7
E. Wire routing sheets	4.8
F. Graphs and Charts	4.9
G. Use of service and parts catalogs	4.10
VII. Electrical Concepts (A.C.)	
A. A.C. Characteristics	5.1
B. Current ratios	5.2
1. Induction	E 5.2.1
2. Lenz' Law	E 5.2.2
3. Transformer types	E 5.2.4
4. Power transformer ratios	E 5.2.6
5. Eddy currents and hysteresis	E 5.2.7
C. Inductive reactance	5.3
D. R.L. circuits	5.4
E. Capacitance	5.5
F. Capactive reactance	5.6
G. R.C. circuits	5.7
H. R.C. and R.L. time constant	5.8
I. Impedance in R.C.L. circuits	5.9
J. Complex numbers	5.10
K. Kirchhoff's Law (A.C.)	5.11
L. Thevenin's and Norton's A.C. network analysis	5.12
M. Resonant circuits	5.13
N. Filter circuits	

Electronics/Electromechanical Technology II

Course Description:	Electronics/Electromechanical Technology II requires 360 contact hours. It is a lecture/laboratory course for senior high school students preparing for the Master Technician Program. Students will design, construct, and analyze amplifier, bridge, and voltage regulator circuits. Solid state devices, such as diodes, SCRs, transistors, LCDs, JFETs, and MOSFETs, will be studied in depth.
Prerequisites:	Electronics/Electromechanical Technology I
Suggested Grade Level:	12
Source:	Master Technician Program (2+2)

Suggested Task/Competency Sequence

6.1 Explore occupations related to electricity and electronics technology.
6.2 Identify (establish) management systems.
7.1 Identify safety rules and use lab equipment and machines safely.
*7.2 Participate in an organized personnel system to manage class and laboratory activities.
*8.1 Participate in AIASA/VICA classroom activities.
*8.2 Investigate community industrial and technical resources.
*8.3 Participate in school (or community) improvement activities.
4.2 Interpret mechanical drawings.
2.1 Explain the operation of a P.N. junction diode.
2.2 Graph the volt-amphere characteristics of a zener diode
2.3 Design a seven-segment display circuit.
2.4 Construct a half-wave rectifier circuit.
2.5 Construct a full-wave rectifier circuit.
2.6 Construct a voltage multiplier circuit.
2.7 Explain the operation of junction transistors.
2.8 Design a voltage-divider bias circuit.
2.9 Design a common-emmitter (CE) circuit.
2.10 Design and construct a common-collector (CC) circuit.
2.11 Calculate circuit characteristics using H parameters.
2.12 Design a class A amplifier.
2.13 Analyze a class B push-pull emitter/follower amplifier.
2.14 Analyze tuned class C amplifiers.
2.15 Construct a voltage regulator circuit.
2.16 Analyze the operation of a JFET circuit.
2.17 Analyze a MoSFET circuit.
2.18 Analyze the frequency response of an AC amplifier.
2.19 Calculate decibel power gain and decible voltage gain.
2.20 Construct an IC regulated power supply.
2.21 Design a Wien-bridge oscillator.
2.22 Plot the I-V charactersitic of an SCR.
2.23 Analyze the operation of a triode vacuum tube amplier.

Electronics/Electromechanical Technology II

Outline and Code

Content Outline	Task/Competency Code
I. Electronics/Electromechanical Technology and Industry	
A. Management systems	6.2
B. Laboratory equipment and machine safety	7.1
C. Industry and community activities	8.1-8.3
D. Career exploration	6.1
II. Electrical Fundamentals (review)	
A. Electrical concepts (D.C.)	1.1-1.5, 1.11-1.14, and 1.16
B. Circuits	1.7-1.10, and 1.15
C. Magnetism	1.17-1.19
D. Fabrication	3.1-3.8
E. Communications	4.1-4.10
F. Electrical concepts (A.C.)	5.1-5.14
III. Solid State Devices and Circuits	
A. PN junction diodes	2.1-2.2
B. Junction transistors	2.7
C. JFETs	2.16
D. MOSFETs	2.17
E. SCR	2.22
F. LEDs	2.3
IV. Rectifier Circuits	
A. Half-wave rectifier	2.4
B. Full-wave rectifier	2.5
V. Voltage and Current Circuits	
A. Voltage multiplier	2.6
B. Voltage divider	2.8
C. Common-emitter (CE) circuit	2.9
D. Common-collector (CC) circuit	2.10
E. Voltage-regulator circuit	2.15
F. H parameters	2.11
VI. Amplifier Circuits	
A. Triode vacuum tube amplifer	2.23
B. Class A amplifier	2.12
C. Class B amplifier	2.13
D. Tuned class C amplifiers	2.14
E. A.C. amplifier frequency response	2.18

VII. Power supplies and oscillators	
A. I.C. regulated power supply	2.20
B. Wien-bridge oscillator	2.21
C. Decible power and voltage gain	2.19

SECTION IV

STUDENT ORGANIZATIONS

Each vocational student organization provides opportunities for students to: (1) exhibit pride in work; (2) demonstrate competencies related to the world of work; and (3) develop leadership abilities, responsible citizenship, and a realistic self-image. These goals are achieved through activities structured within each vocational program and course. Student organizations provide a means through which students become involved in school and community activities, carry out individual or group projects related to career or life goals, and meet with community leaders and employers in a variety of situations. The knowledge, skills, and attitudes developed through these organizations facilitate the students' transition from school to their chosen vocational and to responsible adulthood.

The Carl Perkins Act of 1985, P.L. 98-524, places emphasis on assurance that curriculum development activities will have an impact on instruction in vocational education classrooms. Each vocational service has an appropriate vocational student organization operating as an integral part of that instructional program.

On June 23, 1978, the Virginia State Board of Education approved the following policy standards for operation of vocational education programs:

> A local chapter of the appropriate vocational student organization is operating as an integral part of each vocational program field in the school.
>
> Vocational teachers are serving as advisors to the local chapter or a section of the vocational student organization.
>
> Participation of students in chapter instructional activities is required regardless of whether they are paid members of the organization.

Competency Development in Industrial Arts
Through
American Industrial Arts Students Association

I. Description of the Organization

The American Industrial Arts Student Association, known as AIASA, (pronounced I-A-Sa), is the only student organization devoted exclusively to the needs of Industrial Arts students who are presently enrolled in, or who have completed, Industrial Arts courses. AIASA was started by teachers who wanted to provide opportunities for their students to increase leadership abilities and attain recognition for their achievements. Because AIASA is part of Industrial Arts Education, it has attained the recognition of many teachers' organizations and agencies.

Mission of AIASA. The mission of AIASA is to provide students with an opportunity to become involved with meaningful activities and experiences that prepare them to understand, contribute to, and live in a changing technical world.

Organizational Levels of AIASA. The organization of AIASA begins at the classroom/laboratory level of Industrial Arts. Here students use AIASA activities and learn how to participate in a democratic organization. At the school level, a chapter is organized by and for students who are to be members of an ongoing association of Industrial Arts students. As members of AIASA, students earn recognition for their achievements in Industrial Arts and participate in leadership development and community-service projects.

The regional level and state level of AIASA permit students from different schools to work and learn together through leadership conferences, project exhibits, and competitive events. The national level of AIASA provides opportunities for all members to work and learn together with students throughout the United States of America.

II. Opportunities for Class or Laboratory/AIASA Coordination

A. Leadership Development Activities

Students will acquire an understanding of democratic organizational principles through participation in leadership and followership activities.

1. Introduce students to democratic organization principles used by most groups.
2. Organize in-class officers to lead and manage class.
3. Manage personnel system and routine duties in classroom or laboratory.

4. Conduct class meetings to determine activities/projects for course.

5. Plan activities which apply the Industrial Arts content as class or chapter project.

B. Industrial/Community Resources for Instruction

Students will acquire technical understanding and competencies which lead to responsible consumerism, productive use of leisure time, and improved work skills through contact with technological personnel and resources.

1. Organize class committee to identify resource people and materials related to course content.

2. Invite speaker from industry or community to speak to class.

3. Use industrial personnel to give technical advice to students on activities/projects in class.

4. Obtain supplies, tools, and literature from industry or business in community to supplement laboratory and chapter activities.

5. Display student work in community for public viewing.

6. Arrange field trips to local industry for small groups or class.

C. School/Community Service Activities

Students will develop responsible attitudes toward citizenship and community service through participation in the planning, organizing, and carrying out of activities and projects which contribute to an improvement in or service to the school or community.

1. Organize class committee to identify and plan services needed by others.

2. Select service activity related to content of course.

3. Use mathematics, science, and English teachers to help apply these subjects appropriately in service activity.

4. Make objects or provide service for school, needy persons, or a civic group.

5. Promote participation in a non-profit cause or program of school or community.

6. Demonstrate technical area of course to young students in feeder school.

7. Enjoy socialization between students as they work together to serve someone else.

D. Product or Service Enterprise

Students will become knowledgeable of career opportunities and their requirements through participation in projects which emphasize the private-enterprise system. Policies and procedures of the local school division, as well as community restrictions or guidelines, will govern the type of enterprising activities that any school organization may undertake.

1. Organize class committee to prepare prototypes of products or potential services related to course.
2. Interview principal and other school groups for products/services needed.
3. Organize class as a company related to content of course.
4. Contract to make products for AIASA chapter or other organization to resell or donate.
5. Provide technical service to individuals at a set fee.
6. Determine employment and self-employment opportunities related to enterprise activities.
7. Reproduce a popular student project if it exhibits consumer appeal.
8. Use class treasurer to account for income and disbursements of enterprise.

E. Activities for Recognition

Students will acquire not only an understanding of what constitutes a high standard but also a desire to perform at the maximum levels of their ability through recognition for outstanding artisanship and scholarship.

1. Organize a class committee to prepare a list of contents, and dates for events appropriate to students in class.
2. Introduce all students to contests and AIASA activities.
3. Present in-class awards for outstanding achievements in projects or class assignments.
4. Plan an in-class or department "Open House" to recognize student work.
5. Pre-register individuals or groups in regional fair or spring festival.
6. Prepare and practice for competitive events as class assignments.
7. Invite school and community personnel to judge and advise students.

Competency Development
Through
Vocational Industrial Clubs of America

I. Description of Organization

What is Virginia VICA? The Virginia Association of the Vocational Industrial Clubs of America (VICA) is a vocational organization for students enrolled in trade, industrial, technical, and health occupations courses. Over 250,000 students belong to the national organization. Virginia VICA is the fourth largest state association, with more than 15,000 members.

The Purpose of Virginia VICA. Virginia VICA offers leadership, citizenship, and character development programs and activities to complement skill training available in the public schools and community colleges. Its programs help students better prepare themselves for the labor market. Virginia VICA emphasizes respect for the dignity of work, high standards in trade ethics, work quality, scholarship, and safety. It promotes understanding of the free enterprise system and encourages development of patriotism through the practice of democracy in the club.

How it Works. Students are motivated to learn and excel through opportunities to acquire leadership experience and an understanding of the democratic process; to work together to improve school and community; and to receive individual recognition for both skill and leadership achievement.

II. Opportunities for Class/VICA Coordination

A. Leadership Development Activities

Becoming a professional contains factors other than acquiring a skill. It also involves an increased awareness of the meaning of good citizenship and the importance of labor and management in the world of work. Listed below are several examples of leadership and professional development activities.

1. Plan a school assembly on vocational education and VICA.
2. Host a reception for VICA alumni; have them tell how VICA has helped them in their work experience.
3. Establish an occupational or professional library.
4. Attend a court session or a local government public meeting.
5. Take a trip to a union hall, a local business, another VICA club, or the state legislature.

6. Invite guest speakers from labor and management organizations.
7. Sponsor a Job Fair.
8. Hold a workshop on parliamentary procedures, public speaking, or job interview.
9. Sponsor a debate.
10. Provide training for entries in Skill Olympics leadership contests.

B. Field/Community Resources for Instruction

Using the resources available in the community can add an extra dimension to classroom instruction. Identified below are several groups who can share their expertise with students:

1. General and craft advisory committees.
2. Former students.
3. Professional trade organizations.
4. District and State VICA Officers.
5. Virginia Department of Education personnel.

C. School/Community Service Activities

Letting people know that VICA and its advisors are there and care about the community promotes understanding and goodwill. Several examples of school/community activities are presented below:

1. Invite members of a civic organization to a dinner; join them in a service project.
2. Entertain at an orphanage, hospital, nursing home, jail, or mental institution.
3. "Adopt" a needy family for Thanksgiving; prepare a food basket for them.
4. Work to "get out the vote" at election time.
5. Hold a voter awareness seminar for students of voting age.
6. Plan and carry out a beautification/conservation/renovation project.
7. Collect toys for holiday distribution to needy children.
8. Plan a consumer education program.

9. Plan an assembly on vocational education and VICA.

10. Use National VICA Week to tell the VICA story in the school and the community.

D. Fund-Raising or Enterprise Activities

Planning and participating in fund-raising activities provide the financial means to carry out other projects. Policies and procedures of the local school division, as well as community restrictions or guidelines, govern the type of enterprising activities that any school organization may undertake. The advisor and members should ensure that activities undertaken are of a constructive nature.

E. Activities for Recognition

1. Competitive

Virignia VICA conducts contests on the local, district, and state levels in which students demonstrate the occupational and leadership skills they are learning. The annual Virginia VICA Skill Olympics is the state-level competition, in which 2,000 students compete in 59 occupational and leadership skill areas. First-place state winners represent the Commonwealth at the Annual Unitied States Skill Olympics.

2. Non-Competitive

The Vocational Initiative and Club Achievement Program recognizes the individual student for progress in occupational and leadership development. Students attain different degrees as they progress both in personal growth and in knowledge of their chosen fields of work. The program is designed as a self-paced instructional aid to the classroom activities.

III. Other Programs, Publications, and Applications of VICA to Competency-Based Education

A. Resource Materials

The VICA advisor should become familiar with certain basic VICA resource materials that will serve as aids in the classroom, including the following:

1. Virginia VICA Advisor's Manual
2. Leadership Handbook, Revised, Vocational Industrial Clubs of America
3. Directions, A Guide for VICA Club Advisors
4. Virginia VICA State Level Contests
5. VICA U.S. Skill Olympics Regulations

III. Other Programs and Publications

A. News and Current Information

1. The Virginia Scene for Industrial Arts Students (State AIASA Newsletter)
2. The School Scene (National AIASA Newsletter)
3. Registration Packet for Virginia Industrial Arts Spring Festival.
4. Conference Information for AIASA National Conference.

B. Guides and Resources

1. IA-82-1 AIASA Guide 1: Organizing the Industrial Arts Association, 1980; Explains how to establish and operate an AIASA chapter (66 pages).
2. IA-82-2 AIASA Guide 2: Student Association Activities 2 Industrial Arts Instruction, 1972; Illustrates how to use AIASA activities as a teaching tool (56 pages).
3. IA-82-3 AIASA Guide 3: Advisor's Handbook, 1981; (287 pages)
4. IA-82-4 AIASA Guide 4: Officer's Handbook, 1981; Sections include leadership development, meeting procedures, committees and conference participation (79 pages).
5. IA-82-5 AIASA Guide 5: Annual Program of AIASA Activities, 1981; Identifies the basic activities necessary to have AIASA chapter serve members and achieve goals. Explains regional and local activities (27 pages).
6. IA-82-6 AIASA Guide 6: Standards for AIASA Events, 1981; Identifies permanent rules for AIASA Regional Fairs and the Industrial Arts Spring Festival (92 pages).

C. Audiovisual Materials

1. Art of Communication: How to Conduct a Meeting. State Film #21908
2. Organizaing the Industrial Arts Student Association. Slide/Tape Program
3. Move with Tomorrow (Activities from class to conference.) Slide/Tape Program
4. Organizaing the Industrial Arts Student Association. Transparencies in back of Guide 1
5. In-Class AIASA Management, 3/4" EVT Tape
6. AIASA--A Classroom Experience, National AIASA Alide/Tape Program

6. Achievement Program Guide

7. Parliamentary Procedures at a Glance

B. Audiovisual Aids

Virginia VICA also has two films and a slide presentation available to VICA chapters on a first-request basis:

1. VICA: Going Places - - 15-minutes color/sound 16mm film with original theme music; tells all about VICA for students, community, labor, and management groups.

2. You're Number One - - 5½ minute color/sound 16mm film with music and narration; serves as a motivational film.

3. Achievement Program Slide Kit - - color slides and a script to introduce the program and explain how it works.

Information on ordering the resource materials is available from the Virginia VICA Association, P. O. Box 6Q, Richmond, Virginia 23216, (804) 225-2932.

TRADE AND INDUSTRY
VICA
CLASSROOM MANAGEMENT SYSTEMS

Vocational programs and courses, particularly those in Trade and Industrial Education, contain a large number of competencies and related learning experiences to be mastered by students over a relatively short period of time. A variety of instructional methods and materials may be used to prepare students for entry into an occupation or to teach the basics for continuing education. Therefore, a systematic approach to the management of instruction is required, especially in competency-based vocational programs.

The following questions must be considered when establishing management procedures for competency-based instruction:

1. How and when will students be informed of course or unit objectives and requirements?
2. How will content and instructional activities be sequenced in the course?
3. Will students learn in an independent or group setting?
4. Will a variety of instructional methods and strategies be used?
5. How will laboratory and lecture activities be integrated?
6. How will slow and fast learners be accommodated?
7. How will VICA activities be integrated into instruction?
8. How will students be evaluated and when will the testing occur (pretest, unit test, as a competency is demonstrated)?
9. How and when will student achievement be documented on the competency record?
10. How will recorded competency achievements be made available to future employers?
11. How will students who transfer from another school or program be placed at an appropriate level in the program?

The purpose of this section is to illustrate samples of several classroom management systems developed by teachers incorporating competency-based vocational education techniques into their courses and programs. The systems have been field tested and revised for use in laboratories and classrooms in Virginia.

The following classroom management systems are discussed in this section:

Lesson plans
Student Task Sheets
Learning Contracts
Self-Contained Learning Systems
Task Board Management System

It is important to note that any combination of the above systems may be used by the individual classroom teacher in actual delivery of instruction.

SKILL OLYMPICS

Skill Olympics competitions, sponsored by VICA on the district, state, and national levels, exist for the primary purpose of recognizing vocational student excellence in achievement in the areas of leadership development and occupational skill area. The Skill Olympics program is a means of integrating VICA activities into the classroom.

Following are some of the benefits of participation in the Skill Olympics:

Provides a link between student and community.

Provides a link between student and industry as a potential employer.

Promotes interest and provides incentive to excel in the classroom.

Helps develop pride in work quality.

Aids vocational educators in identifying new technologies, industry needs, and emerging occupations.

Prepares students for world of work through interaction with workers in the field.

The U.S. Skill Olympics program sponsor competitions in the areas of Leadership Development; Health Occupations; Trade, Industrial, and Technical Occupations; and General Contests. There are contests designed for club awards as well as individual competition. District contest winners may advance to the state level, and state winners to the national level; however, some competitions may be held only at the district or state level. National contests are as following:

Leadership Development Contests

Club Business Procedure
Extemporaneous Speaking
Job Interview
Opening and Closing Ceremonies
Prepared Speech

Health Occupations Contests

Dental Assisting
Dental Laboratory Technology
Medical Assisting
Medical Laboratory Technology
Nurse Assisting
Practical Nursing

Trade, Industrial, and Technical Occupations Contests

Air Conditioning and Refrigeration
Air-Cooled Gasoline Engine Repair
Architectural Drafting
Auto Body Repair
Auto Mechanics
Bricklaying
Cabinetmaking and Millwork
Carpentry
Commercial Art
Commercial Food Trades
Commercial Photography
Cosmetology
Diesel Equipment Mechanics
Electrical Trades
Electronic Products Servicing
Graphic Communications
Industrial Electronics
Machine Drafting
Major Appliance Repair
Plumbing and Pipefitting
Precision Machining (Machine Tool Technology)
Sheet Metal
Welding

General Contests

Display
Job Skill Demonstration
Outstanding Club
Safety

Further information on the organization and regulations for the U.S. Skill Olympics may be obtained from Vocational Industrial Clubs of America, Inc., P. O. Box 3000, Leesburg, Virginia 22075.

The Virginia VICA Skill Olympics program offers competitions in addition to those held on the national level. The VICA advisor should be familiar with the regulations on the state level to ensure knowledge of any exception to the national regulations.

The following contests are sponsored by the Virginia VICA State Association:

Leadership Development Contests

Current Events
Essay
Student of the Year

LESSON PLANS

Competency-based education requires that instructional content within vocational education courses be based upon predetermined competencies and objectives. Ensuring the actual achievement of intended course outcomes requires a very high degree of organization in daily planning for instruction. The lesson plan is a most effective tool for organizing and implementing instruction within each class session.

The lesson plan may be viewed as a detailed part of a blueprint for the total course. It ensures (1) that the instructional content for each class session is related to overall course objectives, and (2) that content across class sessions is sufficiently inclusive and sequenced so that predetermined course outcomes are, in fact, achieved. Additionally, it ensures effective use of instructional activities and materials in delivering the instructional content of each class session.

Lesson plan format may vary according to instructor preference or local requirements. The format of the sample corresponds to that of the task/competency frameworks included in the task analyses package developed for many trade and industrial courses (Figure 1) and incorporates job sheets, transparency masters, and tests from Mid-America.

The listing which follows describes the components of the sample lesson plan (Figure 2). Where appropriate, the component is cross-referenced to the corresponding section(s) of the sample framework. Referral to the section in an actual task analyses package can provide the teacher with useful information in developing the lesson plan component.

A blank lesson plan form is also included in this section.

Lesson Plan Components

LESSON TITLE--a brief phrase summarizing the content of the lesson; primarily serves as aid to instructor in readily locating a needed plan.

COURSE--may include more than one listing in cases where a given task/competency identified for inclusion in several courses. (Figure 1, #4)

INSTRUCTIONAL UNIT--a distinct grouping of related task competencies; duty areas may be listed here. (Figure 1, #1)

TASK/COMPETENCY--the knowledge, skills, or attitudes which the learner should possess after the lesson plan is implemented. (Figure 1, #2)

PERFORMANCE OBJECTIVE--a statement of the behavior or performance to be exhibited by the student after instruction, the condition under which the behavior takes place, and the criterion level or standard which the student must meet for task mastery. (Figure 1, #5)

TOOLS/MATERIALS--a listing of any tools, equipment, or supplies that will have to be secured or developed by the instructor in implementing lesson plan activities. (Figure 1, #9)

AUDIOVISUAL MATERIALS--a listing of any nonprint materials used in lesson plan activities. (Figure 1, #10)

REFERENCES--a listing of any printed materials to be used by students in lesson plan activities; may also include resources that are helpful to the instructor in implementing the lesson, but not intended for direct student use. (Figure 1, #11)

STUDENT ASSIGNMENTS--identification of activities the student will complete to reinforce or apply instruction. (Figure 1, #6 and 8)

PRESENTATION--a description of all lesson plan activities, listed in sequence and grouped according to the following types and purposes: (Figure 1, #7 & 8)

- Introduction--to orient, to motivate, to provide continuity
- Presentation--to bring student face to face with the new concept, habit, or skill; to show; to explain; to demonstrate; to relate to learner experience
- Discussion--to clarify, to expand; to reinforce; to correct; to allow learner to verbalize, question, respond, and provide evidence of concept understanding
- Application--to apply, use, or verify concept; to build motor skills; to build habit; to develop attitudes through experiences
- Evaluation--to provide periodic closure; to modify concept; to expand divergent thinking; to summarize; to test

CRITERION-REFERENCED MEASURE--identification of the means of student evaluation and the minimum standard of performance accepted for mastery; should correspond with the performance objective.

SPECIAL NOTES--for instructor's notations concerning evaluation of the plan after it is implemented; may contain suggestions for use of the plan.

SECTION V

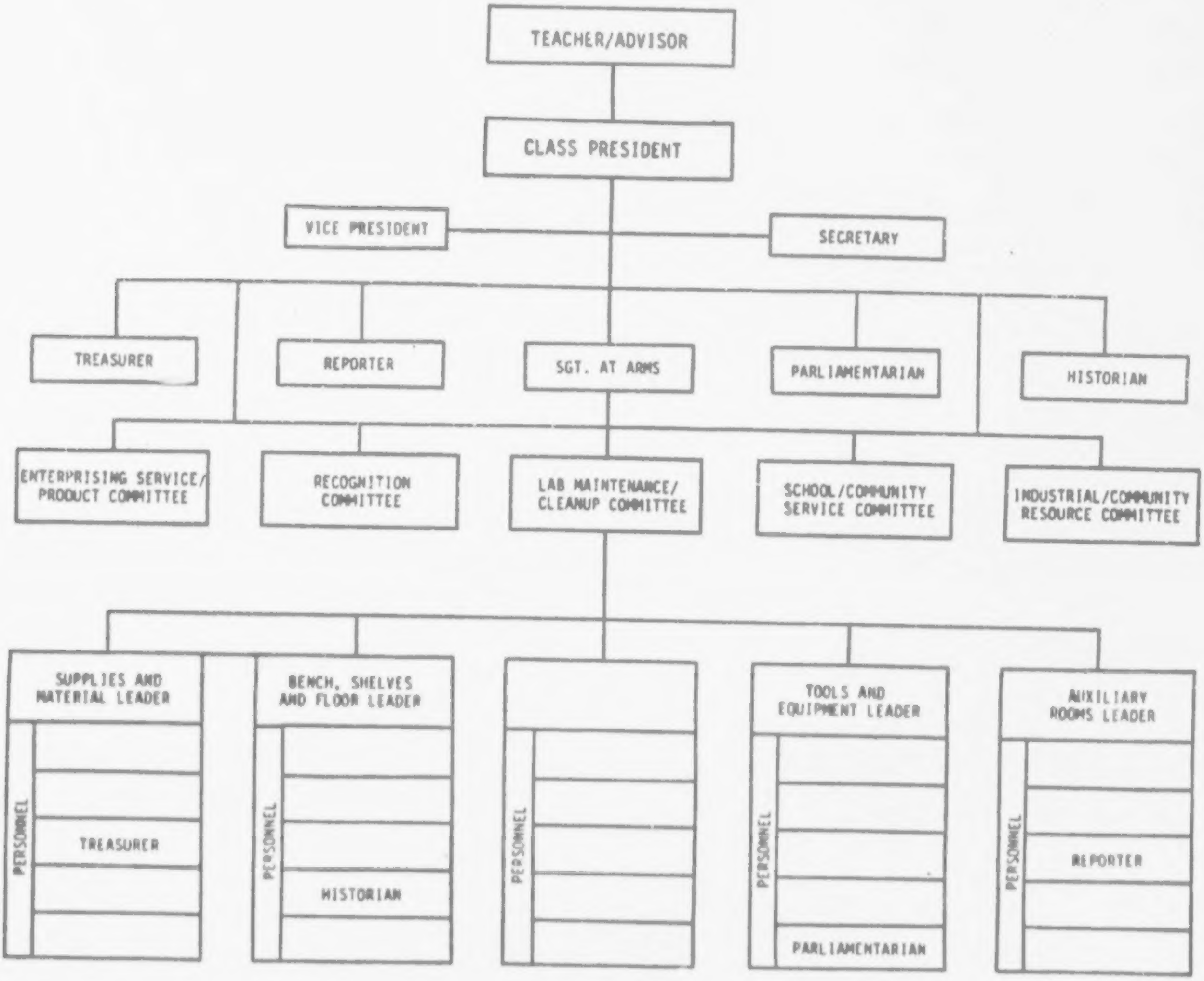
CLASSROOM MANAGEMENT SYSTEMS

If students in vocational courses and programs are to be provided with the instruction necessary for entry into an occupation, then a systematic method of instruction must be applied. Competency-based vocational education courses require an instructional system which may be different from those used in traditional instructional programs.

The purpose of this section is to illustrate one or more examples of classroom management and instructional systems developed by teachers incorporating competency-based vocational education techniques into their courses and programs. The systems have been field tested and revised for use in laboratories and classrooms in Virginia.

STUDENT PERSONNEL SYSTEM

This organization chart is one that illustrates a leadership personnel system for industrial arts classes. The officers carry out their responsibilities while committees coordinate the major types of AIASA activities, which can be part of any class. The teacher may have officers revise this chart to meet the unique class needs and enlarge the chart for classroom display. The duties of officers and committees are suggested on the following pages. Teachers who use the officer/committee system for classroom and laboratory management will be involving every student in the class. This type of organization leads to improved skills, increased knowledge, and better attitudes among students and contributes to their ability to function in the class, other organizations, or in their future work. Activities related to AIASA are described in the student association section of this guide.


TEACHER/ADVISOR
CLASS PRESIDENT
VICE PRESIDENT
SECRETARY
TREASURER
REPORTER
SGT. AT ARMS
PARLIAMENTARIAN
HISTORIAN
ENTERPRISING SERVICE/PRODUCT COMMITTEE
RECOGNITION COMMITTEE
LAB MAINTENANCE/CLEANUP COMMITTEE
SCHOOL/COMMUNITY SERVICE COMMITTEE
INDUSTRIAL/COMMUNITY RESOURCE COMMITTEE
SUPPLIES AND MATERIAL LEADER
PERSONNEL
TREASURER
BENCH, SHELVES AND FLOOR LEADER
PERSONNEL
HISTORIAN
PERSONNEL
TOOLS AND EQUIPMENT LEADER
PERSONNEL
PARLIAMENTARIAN
AUXILIARY ROOMS LEADER
PERSONNEL
REPORTER

AIASA PERSONNEL IN-CLASS DUTIES

PRESIDENT (Student's Name)

1. Is leader of personnel system
2. Calls cleanup
3. Conducts class meetings
4. Receives ideas and reports from the class members
5. Suggests any possible lab improvements gained through experience

VICE PRESIDENT (Student's Name)

1. Is familiar with duties of President
2. Substitutes for President
3. Assists President as second-level manager
4. Helps follow up committee work
5. Helps other officers if absent or behind
6. Makes organization chart for class

SECRETARY

1. Takes roll, makes slip of those absent for teacher
2. Keeps minutes of class decisions for reading at next meeting
3. Records list of officers and committee personnel
4. Prepares agenda for seminar of class meetings
5. Sends letters when necessary

TREASURER

1. Takes care of any revenues and expenditures
2. Takes care of supplies
3. Helps teacher order supplies
4. Cleans supply room
5. Serves on Enterprising Committee of class

PARLIAMENTARIAN

1. Is responsible for general safety procedures
2. Posts safety posters and information
3. Files safety test records
4. Inventories first aid supplies and notifies instructor when additional supplies are needed
5. Reports any injuries to the instructor
6. Helps President with motions and rules of class
7. Serves on School/Community Service Committee of class

SERGEANT-AT-ARMS

1. Oversees all cleanup personnel
2. Makes substitutions for absent cleanup personnel
3. Improvises and receives ideas for improving cleanup
4. Reports to President and teacher when the cleanup is completed
5. Prepares room for class meetings
6. May serve as Quality Control or Union Steward

REPORTER

1. Reports to class on the progress of activities
2. Prepares bulletin board or displays related to class activities of school AIASA
3. Writes articles or makes photos for school newspaper
4. Welcomes visitors and explains classwork
5. Cleans darkroom if available
6. Advertises projects or services of class
7. Serves on Recognition Committee of class

HISTORIAN

1. Picks up homework or assignments for teacher
2. Checks off work turned in by class members
3. Assembles group reports
4. Keeps notebooks, files, or scrapbook up to date
5. Cleans books and reference area of class
6. Photographs activities
7. Serves on Industrial Resource Committee of class

COMMITTEE DUTIES

LABORATORY MAINTENANCE/ COMMITTEE

1. Personnel appointed or rotated to each position by sergeant-at-arms and officers
2. Duties as leader or worker in one of these areas held by students in class:
   (1) Supplies and reference materials
   (2) Tools, equipment, and machines
   (3) Auxiliary rooms
   (4) Other (determined by teacher)
3. Completion of duties reported by workers to chairperson, leader, or sergeant-at-arms
4. Class dismissed at proper time by president, sergeant-at-arms, or teacher.

INDUSTRIAL/COMMUNITY RESOURCE COMMITTEE

1. Makes list of industrial or community resources related to course
2. With teacher, selects three resources helpful to unit of study
3. Reports resources available at class meetings for vote
4. Arranges speakers for visits to class
5. Sends thank-you letters

SCHOOL/COMMUNITY SERVICE COMMITTEE

1. Makes list of classroom, school, or or community service projects related to course
2. With teacher, selects three projects related to technical unit of study
3. Reviews requests from others for services
4. Reports possible projects at class meetings for vote
5. Organizes class for work to be done
6. Delivers service to appropriate person or group

ENTERPRISING SERVICE OR PRODUCT COMMITTEE

1. Makes list of products or services of economic value related to course
2. Makes prototypes of those related units of study
3. Reports possible products or services to class meetings for vote
4. Organizes company for production or service enterprise
5. Keeps financial records and reports to class
6. Presents income for AIASA purpose to treasurer

RECOGNITION OF ACHIEVEMENT COMMITTEE

1. Makes list of regular AIASA contests and others related to course
2. With teacher, selects or develops contests related to unit of study
3. Reports at class meetings on contests to be used
4. Organizes contest procedures and awards to be given
5. Recognizes winners with awards and newspaper articles

LESSONS PLANS FOR
COMPETENCY BASED INSTRUCTION

Every teacher, no matter how competent and experienced, needs to plan the activities of each class session and to reduce this plan into writing. The lesson plan is the appropriate vehicle to be used in organizing the class session. It is the blueprint which ensures that the teacher is prepared to teach; that everything to be taught is set down in the proper order; that the utilization of learning aids, devices, and references has been provided for; and that little is left to chance. The qualify of preplanning determines the quality of the results.

Effective lessons do not just happen. They result from a great amount of effort and time by the teacher who desires to provide an appropriate learning environment for the dissemination of skills and knowledge. Regardless of how long an individual has been in the teaching profession, one should never attempt to make a presentation without a well planned and written lesson or session plan designed for a specific situation. Planning provides the organization necessary for an effective presentation.

The lesson plan is actually a plan of procedure developed by the teacher to be used as a guide in presenting content and one that provides a learning environment for students. It may be referred to as a detailed part of a section of a blueprint of the total instructional package.

The well developed lesson plan is of value not only to the teacher but also to the student, the supervisor, and the administrator. The value goes beyond that of merely knowing which steps come next in a particular presentation. It has value in that it provides a link for all the content included in a course. It is a means for evaluating instruction, for coordinating content with other courses, and for making certain that students are provided the most effective means of learning the content.

Lesson plans are designed and developed so that the instruction will be most effective for the teacher and have greater meaning for the students. The development of the lesson plan is important for many reasons, which include the following:

1. The lesson plan provides a degree of standardization of instruction.
2. It presents a logical and sequential listing of content.
3. It prevents too much, as well as too little, emphasis of selected content.
4. It provides a time schedule which serves as a guideline.
5. It causes instruction to follow accepted practices.
6. It causes teachers to analyze content prior to the presentation.
7. It provides a ready basis for revision.
8. It provides a record of content presented.
9. It coordinates component parts of the lesson.
10. It identifies specific content to be evaluated.
11. It provides for the listing of appropriate student activities.
12. It provides a list of aids, equipment, and references to be used.
13. It provides continuity between the lessons presented within a specific course.

The lesson content and its resulting format have been selected, based upon certain criteria considered in its development. Some of these criteria include the following:

1. The lesson plan fits the particular content of the course.
2. It provides for adequate feedback.
3. It meets the needs of the student.
4. It meets the needs of the teacher.
5. It provides for student involvement at appropriate stages during the course of the lesson.
6. It focuses on a major point or concept to be learned.
7. It contains something new and challenging to the student and something which leads students to advanced learning.
8. It involves content that is appropriate for the student and based on past experiences.
9. It provides for proceeding from the known to the unknown.
10. It provides for accountability of student learning of the content.
11. It provides space for and shows relationship of all supporting instructional materials with tasks involved (aids, instruction sheets, and so forth).
12. It is based on a "five-step" presentation approach of instruction: (1) Introduction, (2) Presentation, (3) Discussion, (4) Application, (5) Evaluation.

Figure 2

SAMPLE LESSON PLAN--Side 1

LESSON PLAN

by

____

Service and Replace Batteries and Battery Parts
Lesson Title

④ Auto Mechanics I (8506)
Course

① Servicing Batteries
Instructional Unit

② **TASK/COMPETENCY: (knowledge, skills, or attitudes student gains from instruction)**

Service or replace batteries, cables, and battery box (Mid-America Objectives 9a and 9b)

⑤ **PERFORMANCE OBJECTIVE: (expected conditions, performance, and criterion or standard)**
Given a vehicle in need of battery service and the necessary tools and equipment, service the battery, battery box, and cables and determine the battery state of charge and condition. All malfunctions identified by the instructor must be recognized and serviced, and the state of charge and serviceability must be identified accurately.

⑨ **TOOLS/MATERIALS:**

- Basic handtool set
- Battery charger
- Battery filler
- Hydrometer or refractometer
- Baking soda & container
- Voltmeter
- Battery components
- Job sheets
- Info sheets

⑩ **AUDIOVISUAL MATERIALS:**

Transparency master, AMII-65B
Also see Automotive Mechanics and Servicing Instructional Resource Guide, page 149.

⑪ **REFERENCES:**

Automotive Mechanics, Vol. II, pp. 57B-81B. Mid-America.
Automotive Mechanics and Servicing Instructional Resource Guide, pp. 148-149.

⑥ **STUDENT ASSIGNMENT(S):**
⑧

Complete activities outlined on Student Task Sheet.

Figure 2

SAMPLE LESSON PLAN--Side 2

PRESENTATION: (Introduction, presentation, discussion, application, & evaluation) ⑤⑧

- I. Introduction
  - A. Safety procedures
  - B. Purpose of batteries
  - C. Parts of battery
- II. Presentation
  - A. AVs
  - B. Transparency from Mid-America
  - C. Demonstrations
    - 1. Activation of dry-charged battery
    - 2. Leakage across top of battery
    - 3. Cell-to-cell voltage test
    - 4. Battery removal, clamp and post cleaning, use of baking soda solution
- III. Discussion
  - A. Causes of battery failure
  - B. Chemical action in battery during charging and discharging
  - C. Temperature effects on battery performance
  - D. Load-testing and use of battery charger
- IV. Application
  - A. Student servicing of battery, cables, and battery box, using Job Sheet #1
  - B. Student removal and replacement of battery, using Job Sheet #2
- V. Evaluation
  - A. Results of activities on Job Sheets #1 and 2
  - B. Performance of this part of Battery Service Test (AM-II, 89B-92B)
  - C. Performance of task as related to CRM (below)

CRITERION REFERENCED MEASURE: ⑦

Service the battery, battery box, and cables and determine battery condition and state of charge. All malfunctions identified by the instructor must be recognized and serviced, and the state of charge and serviceability must be identified accurately.

SPECIAL NOTES: (Resource persons, if any; results and follow-up)

LESSON PLAN

by

Thomas E. Short

Generating Electricity with Light
Lesson Title

Electricity and Electronics Technology
Course

Generating Electricity
Instructional Unit

TASK/COMPETENCY: (knowledge, skills or attitudes student gains from instruction)

4.2 Explain the use of light to generate electricity

PERFORMANCE OBJECTIVES: (expected conditions, performance and criteria)

Given resources, instruction, and supplies, draw a solar cell and explain the theory of its operation in relation to materials used, its polarity, and relationship of light to amount of voltage produced.

EQUIPMENT/SUPPLIES:	VISUALS/STUDENT RESOURCES:
Light-controlled relay Light meter Multimeter Solar cell	Sample solar cells Project kits for students to assemble

REFERENCES:

STUDENT ASSIGNMENT:

Students will select a project kit from those available. Each kit uses a solar cell to create electricity. After making the kit, the student will draw the cell and circuit and explain the operation.

PRESENTATION: (Introduction, presentation, discussion, application & evaluation)

Introduce class to the use of photovoltaic cells to generate electricity from sunlight.

State the objective for the lesson so students know they will need to draw and explain solar cells after they make a project.

Present a demonstration showing a sample solar cell and explain the parts. Discuss situations where solar cells are used. Draw the symbol for photovoltaic cell on chalk board or use transparency. Let students read a photographer's light meter to read the amount of light available for taking a picture.

Ask questions to determine student understanding. Maybe students will list other ways that solar cells are used in watches or radios. Ask students to comment on textbook information.

Assign students to select a solar cell project to build. Kits may be used, or a unique project may be designed. When project is completed, the student will draw cell and the circuit.

Evaluate the projects made by students and grade the drawings of the solar cells and circuits. Listen to students explain solar cell, polarity, and amount of electricity produced.

CRITERION REFERENCED MEASURES:

Draw a solar cell and explain the theory of operation in relation to materials used, polarity, and relationship of light to amount of voltage produced.

STUDENT TASK SHEETS

The student task sheet is primarily intended for use as a handout and may include the following components, as displayed in the sample provided:

- The task/competency statement
- The performance objective developed to correspond to the task/competency
- The enabling objectives, or subtasks, leading to mastery of the overall objective
- The planned learning activity(ies) corresponding to each enabling objective
- A statement of the criterion-referenced measure for the identified task/competency
- Any necessary directions for completing one or more learning activities or tasks
- A section for evaluation of the completed task(s) for recordkeeping and feedback purposes

As a classroom management tool, the student task sheet may provide the following benefits to both the instructor and the student in competency-based education:

- Once task/competencies for a given course have been identified, the instructor may use the student task sheet as a planning form, ensuring that each task is included and adequately planned for in instruction.
- In a group instruction setting, distribution of the completed student task sheet prior to instruction informs the student of upcoming instructional plans and requirements.
- In an individual instruction setting, the teacher can complete all but the learning activities section of the form and allow the student to help select or design learning activities that are both challenging and meaningful.
- The "task instruction" section of the form can be used to give the student any helpful information about the lesson or detailed directions for completing a learning activity or hands-on task.
- The recording of dates and evaluation comments renders the sheet a documentation device for the teacher or a means of feedback for the student.

SAMPLE—SIDE 1

STUDENT TASK SHEET

TASK/COMPETENCY: Service or replace batteries, cables, and battery box

PERFORMANCE OBJECTIVE: Given a vehicle in need of battery service and the necessary tools and equipment, service the battery, battery box, and cables and determine the battery state of charge and condition. All malfunctions identified by the instructor must be recognized and serviced, and the state of charge and serviceability must be identified accurately.

ENABLING OBJECTIVES:	LEARNING ACTIVITIES:	COMPLETED:
1. Describe safety precautions involved in servicing batteries.	1. List in writing safety hazards involved in handling acid, charging, and jump starting.	
2. Identify parts of battery.	2. Observe transparency on battery construction; label diagram of battery.	
3. Relate temperature to battery performance.	3. Listen to lecture.	
4. Explain causes of battery failure.	4. Observe film; participate in class discussion.	
5. Explain chemical action in battery during charging and discharging.	5. Observe film and transparency; read Mid-America information sheets.	
6. Check electrolyte level.	6. Follow Job Sheet #3 if necessary.	
7. Load test battery and use battery charger.	7. Review procedure; follow Job Sheet #4 if necessary.	
8. Activate a dry-charged battery.	8. Observe teacher demonstration; repeat.	
9. Perform cell-to-cell voltage test.	9. Observe teacher demonstration; repeat.	
10. Perform battery leakage test.	10. Observe teacher demonstration; repeat.	
11. Remove battery cable, clean clamp and post, prepare baking soda solution.	11. Observe teacher demonstration; repeat according to Job Sheet #1.	
12. Service battery, cable, and box.	12. Observe teacher demonstration; repeat according to Job Sheet #1.	
13. Replace battery, cable, and box.	13. Follow Job Sheet #2.	

CRITERION-REFERENCED MEASURE:

Service the battery, battery box, and cables and determine battery condition and state of charge. All malfunctions identified by the instructor must be recognized and serviced, and the state of charge and serviceability must be identified accurately.

SAMPLE—SIDE 2

TASK INSTRUCTIONS:

1. Listen and take notes during lectures.
2. Observe films and transparencies.
3. Read information sheets on batteries.
4. Read Job Sheets #1 and 2; review Job Sheets #3 and 4.
5. Observe teacher demonstrations.
6. Perform tests as assigned.
7. Perform replacement, removal, and servicing of batteries as assigned.
8. Take quiz on batteries.

STUDENT EVALUATION:

Completion Date________________

Grade__________________________

Comments:

Figure 1

TASK ANALYSES FRAMEWORK

	Application
DUTY AREA ①	PROGRAM ③
TASK / COMPETENCY ②	COURSE ④

PERFORMANCE OBJECTIVE

⑤

SELECTED ENABLING OBJECTIVES

⑥

CRITERION-REFERENCED MEASURE

⑦

SELECTED INSTRUCTIONAL ACTIVITIES

⑧

SELECTED TOOLS AND MATERIALS

⑨

SELECTED AUDIOVISUAL MATERIALS

⑩

SELECTED REFERENCES

⑪

LEARNING CONTRACTS

The learning contract is a management tool which allows the instructor and the individual student to agree, in advance, upon the components and outcomes of instruction. The typical learning contract contains the following elements:

- The activities to be completed by the student
- The time requirements for completion of designated activities
- The expected quality of the student's performance
- A final grade agreement
- Signature of the instructor and student

The learning contract involves shared responsibility and mutual obligation on the part of the student and the instructor. In essence, the instructor agrees to provide information, directions, materials, and time and to evaluate the student's performance according to predetermined criteria. In turn, the student agrees to perform the stated activities within the time limit and to an expected standard of quality.

Use of the learning contract in competency-based instruction within vocational education classrooms offers the following benefits:

- Learning contracts aid the teacher in organizing instruction so that all identified competencies are covered in the duration of the course. Individual contracts may group related competencies for more efficient use of instructional time.

- Learning contracts allow the teacher and student to take advantage of opportunities to perform jobs outside the classroom; for example, an auto mechanics instructor can schedule instruction on the cooling system when a car needing those repairs is brought into the shop.

- Learning contracts can be tailored to varied levels of student proficiency in both academic and vocational skills.

- Learning contracts meet the competency-based education requirement that students be informed of instructional tasks and performance expectations prior to instruction.

- Students who help formulate their own learning contracts may have increased motivation to perform.

- Student understanding of the world of work is increased by the use of learning contracts, and positive work attitudes such as efficiency, organization, and the acceptance of responsibility are reinforced.

LEARNING CONTRACT

Student:____________________

Course:____________________

I,____,
(name of student)

agree to learn the competencies and complete the projects listed below during the six-week grading period of ________________.
(dates)

Competencies/Projects:

____

____

____

____

____

____

____

____

I further agree that the quality of my completed work must comply with the standards identified for each competency.

I further agree that, upon satisfactory completion of the above, I will receive a final grade of _____ for the stated grading period.
(grade)

________________________ ________________
Student Date

________________________ ________________
Instructor Date

Self-Contained Learning System

Task instruction in competency-based education may be achieved through the use of self-contained learning systems such as modules or learning activity packages (LAPs). A self-contained learning system for a trade and industrial course might contain several packets, each of which is designed for instruction in a group of related competencies. By completing each packet in turn, the student eventually is able to master all task/competencies identified for the course.

Some self-contained learning system packets contain all information, directions, and materials needed by the student for completion of activities. Other packet directions refer the student to the use of additional materials such as texts, audiovisual aids, or tools and equipment, but contain the procedures for use of all materials, whether they are located within or outside the system itself.

The procedural steps for student completion of self-contained learning system packets are represented by the sequence chart on the following page. These suggestions are offered for instructors using self-contained learning systems as a means of instructional delivery in the classroom.

- Teachers should make sure that a variety of instructional and evaluation methods are employed, and avoid situations in which students only read information and respond by writing.
- Students involved in independent use of self-contained learning system packets should be monitored frequently.
- Group instruction and group assignment should be interspersed with individual completion of packets.
- Students who need to review information or repeat learning steps in order to proceed to the next packet will most likely derive greater benefit from activities different from those originally assigned.

SELF-CONTAINED LEARNING SYSTEM SEQUENCE

Student Enters

1. PACKET INTRODUCTION	The student carefully reviews the packet introduction, directions, enabling objectives, and performance objectives.
2. PRETEST	The student completes the packet pretest. If the established minimum score for mastery is obtained, the student proceeds to the next packet (Step 7); if not, the student proceeds to Step 3 within the same packet.
3. INTRODUCTION OF CONTENT	The instructional content of the packet is introduced to the student.
4. EVALUATION OF CONTENT UNDERSTANDING	The student completes a response sheet which assesses his or her mastery of the content introduced in Step 3. If the established minimum score for mastery is obtained, the student proceeds to Step 5; if not, the student reviews content until mastered.
5. APPLICATION OF CONTENT	The student completes an activity designed to apply knowledge of content displayed in Step 4. Activities may include research assignments, project completion, or performance of "hands-on" tasks. When specified standards of performance are met, the student proceeds to Step 6.
6. POSTTEST	The student completes the posttest. If the established minimum score for mastery is obtained, the student proceeds to the next packet; if not, Steps 3 through 5 are reviewed until the minimum score is obtained.
7. NEXT PACKET	Steps 1 through 6 are continued for each successive packet until all system packets have been completed.

TASK BOARD MANAGEMENT SYSTEM

This individualized learning system uses a competency board to enable the student and teacher to identify at any time exactly where the student is in terms of the task sequence for a particular course. It allows the teacher to organize tasks based on availability of equipment and student skill levels, and allows the student to keep track of his or her own progress. It also gives the instructor the flexibility to use locally produced recording forms and to tailor the system to locally identified competencies.

The competency board consists of three elements: a task list (which may comprise several pages, with each task identified by a number; task assignment cards (see Figure 3); and a student nameplate with a hook for each student's cards. The cards may be color-coded to denote varying skill levels. To begin a task, the student obtains a blank task assignment card, fills in the information required, hangs the card on the hook below his or her name, and receives instructions on how to do the task. Instructions may take the form of teacher or advanced-student demonstrations, job sheets from Mid-America, instructor-prepared student task sheets, textbook or operator manual directions, or any other available source. When the student achieves competency in the task, the instructor initials the task assignment card and places the card back on the hook. The instructor records the task grades on a permanent recording form at regular intervals. The student then fills out a new task assignment card, and repeats the procedures.

In programs with a set sequence, such as welding, the student will follow the task list on the board. In programs where the sequence may vary because of equipment availability or customer work, such as small engine repair or auto mechanics, the instructor assigns each task to each student, depending on the student's skill level and individual needs.

Recording Forms: An ideal recording form to accompany the competency board is one which matches each task to a single occupational title or set of titles (see sample Virginia T & I Instructional Management System form in Section IV). The instructor can refer to Section I of this resource, select those occupational titles appropriate to the locality, and as each task/competency is achieved, record the student's grade under the related job title(s). It is strongly suggested that the local craft advisory committee validate the selected occupational titles and their related tasks.

TASK ASSIGNMENT

Name:______________________

Task No.____________________

Starting Date:______________

Completion Date:____________

Remarks:____________________

____

Instructor__________________

Grade: ☐

Figure 3--Task Assignment Card for Task Board Management System

(May Be Color-Coded to Denote Varying Skill Levels)

SECTION VI

RECORDING SYSTEMS

Competency-based vocational education in Virginia requires a system for documenting competencies which have been achieved by each student. This information is essential to the student, teacher, and employer. For the student, it provides a record of successful progress through the vocational program. If the student should transfer to another school or enter the community college system, the record will assist in a smooth transition--eliminating the need to repeat skills and knowledge learned. Therefore, the competency record facilitates articulation between and among vocational progams at different levels of instruction. The teacher uses the competency record for evaluation and planning purposes in the course. Perhaps the most important use of a competency recording system is that it provides specific job-entry informatin to prospective employers.

This section contains information on the characteristics of grading and recording systems for competency-based education. The recording systems were designed by instructors for use by the instructor, student, student records personnel, and the employer. Samples of psychomotor grading systems and a system for combining affective, cognitive, and psychomotor grades are also included.

GRADING

It is generally agreed that grading each competency should go beyond the pass-fail stage and should include an indication of the degree of skill the student has demonstrated. In addition, the grade may be based on more than just the performance (psychomotor) level and include the knowledge (cognitive) and personal behavior (affective) areas. The time required by a student to reach a specific performance level should not be considered in rating a student.

Grades from any system will, of course, need to be converted to the convention A, B, C, D, F system for reporting of grades. The grade for each individual competency must, though, be retained in a student file for use by employers, etc.

Passing (or failing) grades for a course can be accomplished in several ways, such as establishing a minimum number of competencies which must be mastered fully, the number of competencies mastered, or averaging of the scores on only those competencies actually mastered.

CHARACTERISTICS OF GRADE SYSTEMS FOR CBE

1. Students should be graded on their own level of achievement and not in comparison to other students.

2. The minimum acceptable level of achievement should be based on the minimum entry level in the industry or trade.

3. The grading system should be based on nonpunitive strategies. Grades for competencies achieved should not be lowered by competencies not achieved.

4. The system should provide recognition for achievement beyond the minimum level.

5. Both secondary and postsecondary faculty must agree on the same criteria or standards to be achieved for each competency.

6. The evaluation system (letter grade, points, etc.) must be related to the competency criteria standard. For example, the terms excellent, good, average for the letter grades A, B, C, should not be used.

7. The grading composition, percent for attendance, attitude, etc., must be made known to the student. Suggest that three grades be given--one for competency achievement, one for attendance/attitudes, and one for knowledge.

8. A minimum number of competencies should be equated to different letter grades. For example, a student receiving an A grade must also be competent in 90 percent of the competencies for the occupation.

9. The time required for a student to master a competency should not be considered in rating a student except as reflected in #8, above.

10. Letter grades should not be place on competency sheets, but on the official transcript.

11. A point system should be used for all competency-based courses. This would allow for a standard grade translation.

12. Competencies should be grouped and grades averaged for a given set of related competencies (duty areas.)

PSYCHOMOTOR GRADING

4, 3, 2, 1, 0 System

This system is the most widely used and is recommended since it easily converts to the A, B, C, D, F and decimal systems, A being 4 and F being 0. An average of 3.7 would be a grade of 94.25 percent, etc.

4—Highly proficient: The student can complete task quickly and accurately, can direct others in how to do task, and needs only normal supervision.

3—Competent: The student can do all parts of the task. Needs only spot check of completed work, and meets minimum entry level requirements; needs job entry supervision.

2—Partially proficient: The student can do most parts of the task. Needs help only on hardest parts; may not meet all job-entry level requirements for speed and accuracy, and needs close supervision.

1—Extremely limited: The student can do simple parts of task. Needs to be told or shown how to do most of task, and needs extremely close supervision.

0—The student cannot perform any part of task at a level sufficient for participation in a work environment.

X—The student did not attempt the task.

5, 4, 3, 2, 1 System

5—The student completed all parts of the task accurately and independently in less than the allotted time.

4—The student completed all parts of the task with little assistance in the allotted time.

3—The student completed most parts of the task accurately and with some assistance.

2—The student can complete some parts of the task but needs help on most difficult parts.

1—The student's attempt was incomplete or incorrect.

X—The student did not attempt the task.

3, 2, 1, 0 System

3—The student performs task/competency above job-entry level.

2—The student performs task/competency at job-entry level.

1—The student performs task/competency below job-entry level.

0—The student cannot perform task/competency.

X—The student did not attempt the task.

6, 5, 4, 3, 2, 1, 0 System

6—The student can perform this task without supervision or assistance and can lead others in performing it.

5—The student can perform this task without supervision or assistance with initiative and adaptability to special problem situations.

4—The student can perform this task without supervision or assistance with proficiency in speed and quality.

3—The student can perform this task satisfactorily without assistance or supervision.

2—The student can perform this task satisfactorily but requires supervision and/or assistance.

1—The student can perform some parts of this task satisfactorily but requires instruction and supervision to perform entire task.

0—The student has some knowledge and limited experience but not sufficient for participation in a work environment.

GRADING SYSTEM INCLUDING AFFECTIVE, COGNITIVE, AND PSYCHOMOTOR ABILITIES

1. Determine cognitive grade from average of tests and quizzes.
2. Determine affective grade by considering the following on a 4, 3, 2, 1 or 5, 4, 3, 2, 1 or similar system.
    a. Uses correct safety procedures.
    b. Uses time well.
    c. Is punctual.
    d. Follows instructions.
    e. Works well with others.
    f. Takes care of tools, equipment, and building.
    g. Takes pride in workmanship.
    h. Attends regularly.
3. Determine psychomotor grade from a 4, 3, 2, 1 or 5, 4, 3, 2, 1 or similar system.
4. Average the three grades in the following way:

    Psychomotor grade x .5 + affective grade x .25 + cognitive grade x .25 = final grade.

CHARACTERISTICS OF RECORDING SYSTEMS FOR CBE

1. A common recording system should be used at both high school and community college level.
2. The recording system must be an official school record as part of students' permanent files.
3. The recording system must contain a listing of all competencies in the occupational program.
4. A rating system should be used which identifies competencies achieved and the level of performance with an interpretation of the scale.

5. The record should include as a minimum:
    a. occupational title,
    b. signatures of student, instructor, and school official, and
    c. competency list.

Samples of several types of recording forms follow. It should be noted that one form provides for secondary and postsecondary recording of grades for use in an articulated program.

INTERPRETATION OF SYMBOLS AND STUDENT SCORES

PERFORMANCE LEVEL

Proficiency 4:	HIGHLY PROFICIENT: Can complete task quickly and accurately; Can direct others in how to do the task; Needs normal supervision (94%-100%)
Proficiency 3:	COMPETENT: Can do all parts of task; Meets minimum local demands for speed and accuracy; Needs job entry supervision (87%-93%)
Proficiency 2:	PARTIALLY PROFICIENT: Can do most parts of task; Needs help only on hardest parts; May not meet local demands for speed and accuracy; Needs close supervision (79%-86%)
Proficiency 1:	EXTREMELY LIMITED: Can do simple part of task; Needs to be told/shown how to do most of the task; Needs extremely close supervision (70%-78%)
Proficiency 0:	Degree of skill is below minimally acceptable performance level (69% or below)

KNOWLEDGE LEVEL

Knowledge Level a:	OPERATING PROFICIENCY: Can identify, measure, and use troubleshooting techniques, resolving task-related problems; Can evaluate conditions and make proper decisions (94%-100%)
Knowledge Level b:	TECHNIQUES AND PRINCIPLES: Can explain how and when task must be done, why each step is needed; Can interpret written and oral instructions; Can analyze facts/principles (87%-93%)
Knowledge Level c:	PROCEDURES: Can name most steps in task; Needs help interpreting written instructions; Can explain basic facts and state general principles (79%-86%)
Knowledge Level d:	NOMENCLATURE: Can identify parts and tools, and can understand simple facts about task; Can identify related basic facts and terms (70%-78%)
Knowledge Level e:	Amount of knowledge is below minimally acceptable standard (69% or below)

WORK HABITS AND ETHICS

Level A:	Highly acceptable; area where extraordinary strength is shown
Level B:	Very acceptable; area where more than average strength is shown
Level C:	Acceptable; area where average strength is shown
Level D:	Partially acceptable; area where some improvement is needed
Level E:	Not acceptable; area needing considerable improvement

VOCATIONAL EDUCATION
COMPETENCY RECORD

Name of Student ______________________________

School ______________________________

Program Area: ______________________________

Course Title: ______________________________

O. E. Code No. __________

VA Course No. __________

CERTIFICATION OF COMPETENCY

I hereby certify that the student named above has achieved the level of proficiency at the time of testing shown for each of the competencies on the attached list and has completed _____ hours of instruction with an attendance rate of _____ percent.

____
Instructor's Signature

____
Date

ADDITIONAL COMMENTS:

____

____

____

____

____

Page 1 of 3

Name ______________________ Program Area ______________________

Course Title ______________________

Task No.	Task/Competency	Performance 4	3	2	1	0	Knowledge a	b	c	d	e	Date
6.1	Explore occupations related to electricity electronics technology											
6.2	Identify management systems											
7.1	Identify safety rules and use lab equipment and machines safely											
7.2	Participate in an organized personnel system to manage class and lab activities											
8.1	Participate in AIASA/VICA classroom activities											
8.2	Investigate community industrial and technical resources											
8.3	Participate in school or community improvement activities											
4.2	Interpret mechanical blueprints											
4.3	Prepare mechanical drawings											
1.1	Identify the parts of the atom											
4.1	Identify schematic symbols for electrical/ electronic components											
4.4	Prepare an assembly layout drawing											
1.2	Identify conductors, insulators, and semiconductors											
3.8	Construct a chassis											
1.3	Identify resistors											
1.4	Use Ohm's Law											
1.5	Measure resistance, current, and voltage drop in a D.C. resistive circuit											
1.6	Analyze the relationship between R and I in a resistor											
1.7	Identify series circuit characteristics											
1.8	Identify parallel circuit characteristics											
1.9	Identify series-parallel circuit characteristics											
4.8	Prepare a wire routing sheet											
3.1	Demonstrate accepted soldering techniques											

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Name ______________________ Program Area ______________________

Course Title ______________________

Task No.	Task/Competency	Performance					Knowledge					Date
		4	3	2	1	0	a	b	c	d	e	
3.2	Make wire wrap connections											
1.10	Analyze loaded and unloaded resistive voltage dividers											
3.3	Construct a wire harness (interface)											
1.11	Analyze D.C. circuits using Kirchhoff's Law											
1.12	Analyze D.C. circuits using the superposition theorem											
1.13	Use Thevenin's and Norton's theorems											
1.14	Use Millman's theorem											
1.15	Analyze bridge circuits											
1.16	Identify types of batteries											
1.17	Demonstrate the laws of magnetism											
1.18	Explain magnetic hysterisis											
1.19	Determine the magnet polarity of a solenoid											
5.1	Define the characteristics of A.C.											
5.2	Calculate current ratio											
5.3	Calculate inductive reactance											
5.4	Calculate the phase angle in RL circuits											
5.5	Calculate total capacitance											
3.5	Contruct a PC board											
5.6	Calculate capacitive reactance											
5.7	Calculate circuit parameters for an RC circuit											
4.6	Prepare pictorial drawings											
3.6	Install components on a PC board											
5.8	Calculate RC and RL time constants											
5.9	Calculate impedance of RLC circuits											
5.10	Apply complex numbers to A.C. circuit calculations											
5.11	Compute Kirchhoff's Laws for network analysis of A.C. circuits											
5.12	Compute V Thevnin and I Norton for network analysis of A.C. circuits											

Page 3 of ___

Name ______________________ Program Area ______________________

Course Title ______________________

Task No.	Task/Competency	Performance					Knowledge					Date
		4	3	2	1	0	a	b	c	d	e	
5.13	Analyze series and parallel resonant circuits											
3.4	Prepare shielded wire and coaxial cables for installation											
5.14	Analyze filter circuits											
2.1	Explain the operation of a PN junction diode											
2.2	Graph the voltampere characteristics of a zener diode											
2.3	Design a seven-segment display circuit											
2.4	Construct a half-wave rectifier circuit											
2.5	Construct a full-wave rectifier circuit											
2.6	Construct a voltage multiplier circuit											
2.7	Explain the operation of junction transistors											
2.8	Design a voltage-divider bias circuit											
2.9	Design a common-emitter (CE) amplifier											
2.10	Design and construct a common-collector (CC) amplifier											
2.11	Calculate circuit characteristics using H parameters											
2.12	Design a class A amplifier											
2.13	Analyze class B push-pull emitter follower amplifiers											
2.14	Analyze tuned class C amplifiers											
2.15	Construct a voltage regulator circuit											
2.16	Analyze the operation of a JFET circuit											
2.17	Analyze a MOSFET circuit											
2.18	Analyze the frequency response of an AC amplifier											
2.19	Calculate decibel power gain and decibel voltage gain											
2.20	Construct an IC regulated power supply											
2.21	Design a Wien-bridge oscillator											
2.22	Plot the I-V characteristics of an SCR											
2.23	Analyze the operation of a triode vacuum tube amplifier											

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APPENDICES

Appendix A: Selected Audiovisual Materials

Appendix B: Tools and Equipment

Appendix A

Selected Audiovisual Materials

A. Audiovisual Services, Virginia Department of Education, P. O. Box 6Q,
Richmond, VA 23216

Art of Communications: How to Conduct a Meeting (#21903) (film)
Auto CAD: Electronic Drafting (filmstrips/cassettes)
Careers in Industry (#79912)
Electricity and How it is Made (#18609)
Electricity--Fundamentals of Electricity (#42809)
Electricity--Production (#93308)
Electricity--Static (#96205)
Electromotive Force Series (#71708) (film)
Electronics--The Future and You (#03508) (film)
Electronics at Work (#88208) (film)
Electrostatic Charges and Forces (#79808) (film)
Magnetism (#75505) (film)
Magnetism and Electricity (#09809) (film)
Molecules--A First Film (#52906) (film)

B. American Radio Relay League, Newington, CT 06111

Lissajous Figures (TVK30-212B)

C. Bergwall Productions, Garden City, N.Y. 11530

Basic Electricity and Electronics: Alternating Current (filmstrips/cassettes)
Basic Electronic Test Instruments (filmstrips/cassettes)
Basic Electricity and Electronics: Direct Current (filmstrips/cassettes)
or 6-5¼" floppy disks; hardward needed: Apple II+48K, IIe, IIc)
Basic Electricity and Electronics: Reactive Circuits (filmstrips/cassettes)
Basic Drafting (filmstrips/cassettes)
Basic Drafting II (filmstrips/cassettes)
Basic Drafting III (filmstrips/cassettes)
Bench Metalwork (filmstrips/cassettes)
Daul Trace Oscilloscope (filmstrips/cassettes)
Electronic Power Supplies (filmstrips/cassettes)
Measuring Tools Explained (filmstrips/cassettes)
Pneumatics Explained (filmstrips/cassettes)
Soldering for Electronics Repair (filmstrips/cassettes)
Transistors (filmstrips/cassettes)
Soldering Principles (filmstrips/cassettes)

D. BFA Educational Media, 468 Park Avenue South, New York, N.Y. 10016

People Who Work in Manufacturing

E. Bureau of Audiovisual Instruction, University of Wisconsin Extension, Madison, WI 53706

Electricity: Fundamentals (film)
Electricity: How is it Generated (film)

F. Career Aids Inc., 8950 Lurline Avenue, Chatsworth, CA 91311

Basic Electrical Circuits (filmstrips/cassettes)
Basic Electricity (filmstrips/cassettes)
Careers in Electricity (color-sound filmstrip)
Careers in Electronics (color-sound filmstrip)
Components of A.C. Circuits (filmstrip)
Measuring Electricity
Oscilloscope Operations (filmstrips/cassettes)
Oscilloscopes and How to Use Them (filmstrips/cassettes)
Solving Basic D.C. Circuit Problems filmstrips/cassettes/workbooks/ study guide)

G. DCA Educational Products, 42 Valley Road, Warrington, PA 18976

Alternating Currents (transparencies)
Basic Pentode Amplifier (transparencies) (E-94)
Basic Triode Amplifier (transparencies) (E-95)
Coupling Between Stages (transparencies) (E-96)
Inductance (transparencies)
Oscillators (transparencies)
Push-Pull Amplifier (transparencies)
Semi-conductors and Transistors (transparencies)
Vacuum Tube Applications (transparencies)
Voltage Sources (transparencies)

H. Technology Education Service, Virginia Department of Education, P. O. Box 6Q, Richmond, VA 23216

In Class AIASA Management (TV tape)
Move with Tomorrow (slides)

I. Mid-America Vocational Curriculum Consortium, 1500 West Seventh Avenue,
Stillwater, Oklahoma 74074

Circuit Reduction (transparency)
Combined Series Circuit (transparency)
Current Flow in a Parallel Circuit
D.C. Current Scale and Range Switch on Typical Ammeters (transparency)
Finding Current in a Parallel Circuit (transparency)
Circuits (transparency)
Kirchhoff's Law of Voltage (transparency)
Memory Wheel for Solving Problems (transparency)
Ohm's Law (transparency)
Ohm's Law--Computing Current (transparency)
Ohm's Law--Magic Circle (transparency)
Ohmmeter Scale and Range Settings (transparency)
Resistance in Parallel Circuits (transparency)
Series-Parallel Circuits (transparency)
Series-Parallel Circuit and Equivalent Circuit (transparency)
Simple Series Circuit (transparency)
Steps to Simplify a Series-Parallel Circuit (transparency)
The Receiprocal Resistance Method (transparency)
The Atom and its Particles (transparency)
Using the Ammeter in a Circuit (transparency)
Voltage Divider (transparency)
Voltage Drops (transparency)
Voltmeter Scales and Range Settings (transparency)

J. Milner-Fenwick, Inc., 3800 Liberty Height Avenue, Baltimore, MD 21215

The Oscilloscope (super 8mm filmloop series)

K. National AIASA, 1908 Association Drive, Reston, VA 22091

AIASA--A Classroom Experience (slides)

L. National Audiovisual Center, Washington, D.C. 20409

Amplifier Principles Parts 1 and 2 (films)
Basic Circuit Symbols and Components--Battery Circuits (U.S. Air Force film)
Blocking Oscillator (film)
Capacitors (TVK30-209) (film)
Electron Coupled Oscillator (film)
Oscilloscopes--Frequency and Measurement (U.S. Air Force film)
Pentode Crystal Oscillator (film)
Phase Shift Oscillator (film)
Printed Circuits and Their Repair (U.S. Air Force film)
Resistors--Construction (U.S. Air Force film)
Vacuum Tubes (film)
Wein Bridge Oscillator (film)

M. RMI Media Productions, 120 West 72nd Street, Kansas City, MO 64114

Electrical Safety in the Shop (filmstrips/slide set/videotape)

N. Teaching Aids, Inc., P. O. Box 1798, Costa Mesa, CA 92626-0798

Bipolar Transistor (transparencies)
Electronic Multimeters: Function and Use (filmstrip
Fundamentals of Alternating Current (filmstrips/cassettes)
Measuring Electrical Quantities (filmstrips/cassettes)
Printed Circuits (filmstrips/cassettes)

Appendix B

Tools and Equipment

The following tools and equipment have been listed for instructional planning and facility development. The list includes all tools and equipment necessary for teaching the competencies contained in this guide.

Item No.	Basic Items Quantity	Description
1	1	A. EQUIPMENT
1	1	Instructor's electrical demonstration bench
2	1	Electrical work bench with 110 volt power strip and lockers
3	1	Sheet metal bench with vises
4	8	Student electrical work bench; 1 station with lockers and power service
5	24	Student stools
6	2	Textbook cases
7	1	Test equipment cabinet
8	2	Small parts cabinets
9	4	Standard work tables
10	1	Electrical hand tool cabinet with appropriate electrical tools
11	8	Galvonmeters
12	1	Drill press
13	2	Electric hand drills
14	1	Small table top bench grinder
15	1	Small table top sheet metal shear
16	1	Small table top sheet metal box and pan brake
17	1	Small table top sheet metal notcher
18	2	File cabinets
19	2	Multipurpose storage cabinets
20	8	Digital multimeters
21	8	Volt-Ohm meters (analog)
22	8	Signal generators R.F.
23	9	Signal generators A.F.
24	1	Tube tester
25	1	LRC bridge
26	1	Transistor curve tracer
27	8	Daul trace-multipurpose oscilloscopes
28	16	D.C. power supplies (low voltage)
29	8	D.C. power supplies (low voltage)
30	1	Light table
31	8	Variac (5 amp)
32	8	Isolation transformers

B. TOOL/APPARATUS SUPPLIES

1	20	Soldering pencils
2	20	Needle nose pliers
3	20	Diagonal/sidecutters
4	20	Wire strippers
5	10 sets	Assorted screw drivers
6	10 sets	Nut drivers, 5/16-1/2
7	1	English SAE tap and die set
8	1	Meter MKS tap and die set
9	2	Chassis punch sets
10	20	Craft knives
11	20	T-squares
12	20	45°-90° triangle
13	20	30°-60° triangle
14	16	Bread board devices (perf board)
15	20	6" compasses
16	20	Solder vacs
17	20	Lead benders
18	20	Soldering iron (pencil) holders with sponges
19	20	Soldering aids (non-metallic)
20	8	P.C. board vise
21	2	Luxo lamp
22	8	Micrometer (0-1")
23	1	Anti-static work station

C. EDUCATION MEDIA

1	1	Overhead projectors
2	1	Projection screen
3	1	Cassette tape recorder
4	1	Carousel slide projector
5	1	Filmstrip projector
6	1	16mm film projector
7	1	Dukane filmstrip/cassette projection unit (can be used in place of items 3&5)
8	1	Video playback/recorder
9	1	Video monitor
10	1	VICA or AIASA chapter banner
11	1 set	VICA or AIASA office symbols
12	1	Robert's Rules of Order